S. HRG. 111–1215

LEGISLATIVE HEARING ON S. 1733, CLEAN ENERGY JOBS AND AMERICAN POWER ACT

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

OCTOBER 28, 2009

Printed for the use of the Committee on Environment and Public Works

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COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED ELEVENTH CONGRESS
FIRST SESSION

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LEGISLATIVE HEARING ON S. 1733, CLEAN ENERGY JOBS AND AMERICAN POWER ACT

WEDNESDAY, OCTOBER 28, 2009

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

The full committee met, pursuant to notice, at 9:30 a.m. in room 406, Dirksen Senate Office Building, Hon. Barbara Boxer (chairman of the full committee) presiding.

Present: Senators Boxer, Inhofe, Baucus, Carper, Lautenberg, Cardin, Sanders, Klobuchar, Whitehouse, Udall, Merkley, Gillibrand, Specter, Alexander, Voinovich, Bond, Barrasso, and Crapo.

Senator BOXER. The meeting will come to order. We are very happy to see the witnesses here. We are going to have 2 minute openings today and rounds of 5 minutes each. I am going to pass on an opening statement and call on Senator Cardin.

OPENING STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR FROM THE STATE OF MARYLAND

Senator CARDIN. Well, Madam Chair, let me just thank all of our witnesses that are here, and I am really looking forward to today's hearing.

We are going to have a chance to talk about jobs and economic opportunity, national security, utilities and adaptation. I am particularly pleased that on the fourth panel Secretary Shari Wilson—and I will have a little bit to say about her later—the Secretary of the Maryland Department of the Environment, because I am proud of what Maryland has done in the leadership on global climate change establishing its own State program on climate change, and I think it is going to be very helpful to the committee.

Let me just underscore, I guess, two points, Madam Chair, as we start the second day of hearings on the legislation that you have brought forward.

First, this is a bill that will create jobs in our community. I mentioned yesterday what is happening in White Marsh with new battery technology for the auto industry. We are very proud of that technology. We are very proud of the jobs it is creating in my own State of Maryland. We see this as a real opportunity to expand technology that was developed in the United States, to keep jobs and create jobs in America.

And second, let me just bring to the committee's attention an article that appeared in the Washington Post this morning about the impact on coastal areas of global climate change with rising sea levels. And they talk about the risk to the natural environment in the State of Maryland as well as to the residential development along our coast.

This is an urgent issue, Madam Chair, that needs to be dealt with now, for the sake of our national security, for the sake of our environment, for the sake of the property values of people who live in the coastal areas. For all these reasons, it is important that we get the job done this year, and I applaud you for your leadership.

Senator BOXER. Thank you so much.

Senator Inhofe.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Senator INHOFE. I would very much like to inquire as to what we are doing here. Our side feels very strongly that they would like to have 5 minute openings. Since we have four panels, it is an all day situation. Would that be acceptable?

Senator BOXER. Well, Senator, let me explain——

Senator INHOFE. I do not plan to take that much——

Senator BOXER. Well, yesterday we were here for quite a while. We have four panels today. Is that right, four? So, we did get to speak a lot. I have waived my opening time. We have 2 minutes. If a Senator feels they must go over a minute, I am not going to shut them down. So, why do we not just go? I have given up my time, but you go right ahead.

Senator INHOFE. All right. That, well——

Senator BOXER. So, if you go over a minute, that is fine.

Senator INHOFE. Well, anyway, we are going to have a lot of discussion hopefully today about jobs and get out of some of the personal attacks and those things that we had to experience yesterday.

I do look forward to the number of witnesses that we have. We have some from Valero Energy, which I consider to be very well informed on the problems that exist out there and how we are going to meet those problems, as well as the Virginia Manufacturers Association, both to talk about how the recession has hurt their operations and their employees. And they will talk about how the Waxman-Markey bill will make things even worse, less refined products produced here in America and fewer jobs.

I think some of these things we do understand. I would only say this about yesterday, that I thought it was a little bit overbearing to have spent 30 minutes just having Senator Kerry talk about how the world is coming to an end, and the only way to save the world is to pass the largest tax increase in history. And I do not think that is realistic.

I would say this, though, to my good friend, the Chairman of the committee, that if you look at the polling data, the American people have caught on. I mentioned yesterday that it was kind of strange that after the August recess 60 days ago, everyone was really uptight because they had heard from the American people. But now they have forgotten what the American people have said.

However, the polling data, now I am looking at it right now, I have been in kind of shock. The most recent poll just last week came out in Politico is 45 percent of the people rate the economy as the most important issue, then they go on down to 21 percent on spending, 20 percent on health care, 9 percent on the wars, just 4 percent on climate change.

So, I think there is an awareness out there that has not been there before, Madam Chairman, and I am somewhat rejoicing in that. I give back my time.

Senator BOXER. Thank you very much.

Senator Specter.

OPENING STATEMENT OF HON. ARLEN SPECTER, U.S. SENATOR FROM THE STATE OF PENNSYLVANIA

Senator SPECTER. Thank you, Madam Chairwoman.

My comments will be limited to introducing the distinguished Mayor of Philadelphia, who is on the panel. Mayor Nutter is the 98th Mayor of the city of Philadelphia. It is interesting to visit the Mayor's reception room to see his 97 predecessors on the wall. It is a long, distinguished and illustrious group.

Philadelphia is the sixth largest city in the country. In 1938, Philadelphia was the biggest city in the country. With Mayor Nutter's leadership, we are going to move up to five, four and [unclear] surpassing one of the cities, New York, to the World Series where the Phillies will be undertaking an important venture on behalf of our city a little later today.

[Laughter.]

Senator SPECTER. But the Mayor brings a very important perspective to a very critical issue. He has a background from the Wharton School of Business, became politically active, worked on the City Council, elected in 1991, and now elected to the Mayor's job.

I have worked with him very closely for many years and look forward to his testimony and his continued outstanding leadership of our great city.

Thank you, Madam Chairwoman.

Senator BOXER. Thank you so very much.

And next is Senator Alexander.

OPENING STATEMENT OF HON. LAMAR ALEXANDER, U.S. SENATOR FROM THE STATE OF TENNESSEE

Senator ALEXANDER. Thanks, Madam Chairman.

Sometimes a story helps. A couple of weeks ago, I was visited by the Chairman of a French company who is the largest maker of turbines in the world for nuclear plants. He told me, of course, France gets 80 percent of its electricity from nuclear power. We hear a lot about Germany and solar. Germany gets 1 percent of its electricity from solar.

France gets 80 percent from nuclear power, and Germany is buying power from France. And jobs from Spain are moving to France because France has among the lowest electric rates in Europe. And it has among the lowest carbon emissions in Europe. That is France.

This French company is selling, because of all of the technology they have developed in France over the last 30 years while we have not started one new nuclear plant, France is selling turbines all around the world. To Russia, India, the countries that are developing power, but especially in China. This French president of the company told me that China is starting a new nuclear plant every 3 months. China is building 132 nuclear plants, and we have not started one in 30 years.

My objection to this bill is—I see the problem. I agree with the problem. But I see no need for us to send manufacturing jobs overseas by deliberately raising prices of electricity by putting a cap and trade on fuel which raises the price of carbon but does not reduce carbon.

Deliberately raising rates and relying on solar and wind when we have had 60 years of experience with nuclear power, invented it, and by building 100 new nuclear plants in 20 years and electrifying half our cars and trucks in 20 years, and doubling our energy research and development on recapturing, on how to capture carbon from coal plants, on how to make solar, which is now four or five times the cost of other electricity in our region, cost competitive, on making better advanced batteries and on recycling used nuclear fuels.

If we build 100 nuclear plants, the President led us to do that, if you led us to electrify half our cars and trucks, if we had mini-Manhattan Projects on alternative energy, we could reach our carbon goals by 2030 without a national energy tax, without sending jobs overseas, and without imposing on Americans higher costs for the energy and electricity.

So, my final question, as my 3 minutes comes to an end, is, if the United States were to create a nuclear navy in the 1950s, which we did, and it had led the world for 60 years, which it has, and if it had done everything we wanted it to do, and if sailors have lived safely on top of it for all that time, then if we wanted to continue to have a strong military, would we stop building nuclear ships and start subsidizing sailboats? No, we would not.

So, my question is, I do not have a problem with the problem, but why are we developing this solution when we have another one staring us right in the face?

I look forward to hearing from the witnesses on that subject.

Senator BOXER. Senator Klobuchar. Welcome.

OPENING STATEMENT OF HON. AMY KLOBUCHAR, U.S. SENATOR FROM THE STATE OF MINNESOTA

Senator KLOBUCHAR. Thank you very much, Madam Chairman.

I would like to welcome all of our panelists, especially from the State of Minnesota, Dave Foster, who has been at this for a long time. He heads up the Blue Green Alliance, and he has worked representing miners in Minnesota for nearly 7 years. As you know, my grandpa was an iron ore miner, worked a thousand feet underground in the mines in Ely, Minnesota, and at the same time always had that respect for the outdoors and loved to hunt and loved to fish.

And so, when Dave had this idea of starting up this BlueGreen Alliance, which is a combination of the workers in our State and the environmental groups to say we can have a net gain here, we can do this together, we can actually do things that are good for the environment and bring jobs in at the same time, at the time was rather novel. I remember Paul Wellstone leading rallies with Dave on this topic.

And now we have actually seen it in our State, as I was saying yesterday in my opening. We have seen a huge increase in our green jobs, as compared to a lot of our other jobs in our State. We have a 25 percent by 2025 renewable electricity standard that has brought all kinds of jobs into our State. And we are seeing iron ore mines finally with this economic recession starting to open up again, and before that time, were actually doing better than they had in decades. We have seen how we can make this work together, and that is what Dave stands for.

And to have all of these steelworkers standing there saying they want to see an energy bill is a great thing in our State.

So, thank you very much for being here, Dave, and I look forward to hearing from the Mayor and the rest of the panelists as well.

Senator BOXER. Senator, thank you very much.

Senator Voinovich.

OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Senator VOINOVICH. Thank you, Madam Chairman.

The impact of this legislation on jobs, workers and Ohio families is at the height of my concerns with this legislation. Again, it seems to me we are failing to harmonize our environment, energy, economic and national security interests. The bill will cost my State of Ohio and the country jobs. This is without dispute, despite wild claims of green job creation. There is no credible analysis that suggests that this bill will be a net job creator.

In fact, this legislation includes a form of unemployment insurance for those who will lose their jobs because of its implementation. It is very disturbing that this is included in what proponents call a jobs bill. Ohio has already lost enough jobs, and some of it is because we have switched from coal to natural gas.

The job losses also will stem from the bill's onerous mandates and requirements. Further, the Senate Energy Committee passed a bill containing a mandatory renewable electricity standard, or RES, and the majority leader has indicated that he is going to merge that with this bill. This creates a system of overlapping and redundant requirements that will inhibit the cost effective admission reductions and will drive energy prices up.

Indeed, the theory under cap and trade is that we set a cap and allow companies to comply with the most efficient means possible. No so with this bill.

The other things that I would like to mention is that there are provisions in here for what we call a border tax, or border adjustment. We have researched this thoroughly, and those provisions violate the WTO. What we are really going to need, Madam Chairman, is an international agreement that would deal with those countries that fail to comply with the new standards that the countries will set, very much like we had with nuclear proliferation arms reduction.

And so much of what we should be doing here is going to be reflected upon what comes out of Copenhagen in December. And that is why I think it is really important that we understand for us to unilaterally pass this legislation without airing some of the major problems that we have, for example, whether we are going to use the year 1990 or the year 2005 to determine what are caps are going to be, is something that needs to be discussed.

We also need to deal with allowances and whether they are going to be paid for or not paid for. Senator Alexander mentioned France. France wants no allowances, no free allowances. They want the allowances to be paid for. Germany, on the other hand, has said we have to have allowances so we can predict steel in our manufacturing.

So, these things are going to have to be worked out on the international level if we expect to make some sense out of our efforts to reduce greenhouse gases, not only in this country but in the world.

[The prepared statement of Senator Voinovich follows:]

STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

The impact this legislation will have on jobs, workers and Ohio families is at the heart of my concerns with the Kerry-Boxer proposal. Again it seems we are failing to harmonize our environment, energy, economic and national security concerns.

That this bill will cost my State of Ohio and the country jobs is without dispute. Despite wild claims of green job creation, there is no credible analysis that suggests that this bill will be a net job creator. In fact, this legislation includes a form of unemployment insurance for those who will lose their jobs because of its implementation legislation. It's very disturbing that this is included in what proponents call a "jobs bill." Ohio has already lost too many jobs, with unemployment now at 11 percent.

The job losses will stem from the bill's onerous mandates and requirements. Further, the Senate Energy Committee passed a bill containing mandatory renewable electricity standard, or RES, and the majority leader has indicated his intent to merge the cap/trade bill and the energy bill together.

This creates a system of overlapping and redundant requirements that will inhibit cost effective emissions reductions and will drive energy prices up. Indeed, the theory under cap and trade is that we set a cap and allow companies to comply by the most efficient means possible. Not so with this bill. Here, we set a cap and then mandate how companies comply.

Residential consumers, small businesses, manufacturers and industrial operations all depend on reliable and affordable energy. The consequences of fuel switching from coal to natural gas are particularly troubling for our industrial workers and for vulnerable consumers like the elderly and those living in poverty. Our environmental policies have already resulted in a sharp increase in the use of natural gas for electric power generation—accounting for almost 94 percent of the increase in domestic demand for natural gas since 1992.

As history has proven, the demand for natural gas can send ripple effects throughout the economy because of its use as both a fuel and a feedstock for the production of everything from fertilizer, to plastics, to the heating of homes. It has contributed to a loss of over 3.1 million U.S. manufacturing jobs.[1] In fact, the recession in Ohio began in 2001 when natural gas demand spiked. As an example, the chemistry industry has gone from a $19 billion trade surplus in 1997—the most successful export industry in U.S. history—to becoming a net importer of chemicals.

I find provisions in the bill that actually encourage fuel switching particularly short sighted. In fact, a CEO of one of the Nation's largest utilities told me that we would regret the move to natural gas as it will hamper our manufacturers and create a "leap-frog" effect over much needed investments in CCS and nuclear technologies.

Many people down-play the impacts that this policy will have on our economy. And although the "green jobs" movement is trying to convince us that rationing energy resources will save the world and our economy, there is little to support these claims.

[1] U.S. Department of Labor.

As I mentioned yesterday, the American Council for Capital Formation (ACCF), having performed the only comprehensive analysis of the Waxman bill that I'm aware of, concluded that by 2020 the House bill could reduce household income in my home State of Ohio by up to $261 per year on average, increase energy costs by up to 20 percent, and result in a net loss of more than 100,000 jobs.

Under this bill, these numbers are sure to go up. This is because the 2020 cap is tighter, the pool of distributed allowances is smaller, and there is no Clean Air Act or State program preemption. Today, I'd like to ask to have the entire ACCF report submitted for the record.

Recognizing that the bill will put U.S. manufacturers at a disadvantage to overseas competition, proponents seek to offset compliance and fuel and input costs through a system of rebates. Yet many manufacturers from my State won't qualify for the rebates, and the bill's costly requirements will force plant closures and relocation overseas. These include tire, semi-conductor, textile manufacturers and refiners, for example.

This is bad for the environment and the economy. Some of my colleagues would like to insulate our Nation's manufacturers by including a "border tariff" provision. But this is likely inconsistent with WTO requirements.

My goals throughout this process are to keep Nation's economy, and that of Ohio, on a sure footing while decreasing emissions. This bill just doesn't get the job done and in fact is a threat to the jobs and economy.

[The referenced analysis follows:]

Analysis of
The Waxman-Markey Bill
"The American Clean Energy and Security Act of 2009"
(H.R. 2454)
Using
The National Energy Modeling System
(NEMS/ACCF-NAM 2)

A Report by the
American Council for Capital Formation
and the
National Association of Manufacturers

Analysis Conducted by
Science Applications International Corporation (SAIC)

ACCF
AMERICAN COUNCIL FOR CAPITAL FORMATION

NAM National Association of Manufacturers

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EXECUTIVE SUMMARY

The American Council for Capital Formation (ACCF) and the National Association of Manufacturers (NAM) believe it important to fully and realistically examine the potential costs that enactment of the Waxman-Markey bill, "The American Clean Energy and Security Act of 2009" (H.R. 2454)[1], would impose on the U.S. economy. It is well recognized that the cost to U.S. consumers and employers of implementing greenhouse gas (GHG) emission reductions is highly dependent on the market penetration achieved by key technologies and the availability of carbon offsets by 2030. Understanding the potential economic impacts at the national, state and individual household levels can help guide choices on climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies need to include consideration of impacts on energy security, economic growth, and U.S. competitiveness. This project is designed to assist in this effort.

This analysis was undertaken by ACCF and NAM using NEMS/ACCF-NAM 2[2], the version used in this project of the National Energy Modeling System (NEMS) model, the model used by the U.S. Energy Information Administration (EIA) for its energy forecasting and policy analysis. ACCF and NAM applied input assumptions under two scenarios (high cost and low cost) investigating the sensitivity of assumptions that have proven in the past to significantly impact the cost of limiting CO_2 emissions from energy. The ACCF-NAM input assumptions embody judgment on the likely cost and availability of new technologies in the early decades of a long-term effort to reduce greenhouse gas emissions as well as energy efficiency and renewable electricity standards. These assumptions include the availability of nuclear power technology for electric generation, the availability of carbon capture and storage for more efficient coal and natural gas-based power generation technologies, the availability of wind and biomass technologies. The ACCF-NAM input assumptions also included assumptions regarding the likely availability of domestic and international offsets - - key factors influencing analysis of the cost of limiting greenhouse gas emissions.

Overview of Findings in the ACCF-NAM Analysis of the Waxman-Markey Bill (H.R. 2454)

The NEMS/ACCF-NAM 2 model study's findings indicate substantial and growing impacts to consumers and the economy of meeting the increasingly stringent emission targets through 2030 established by H.R.2454. Among the NEMS/ACCF-NAM 2 study's general findings are:

- ***U.S. economic growth slows:***

U.S. economic growth slows under the Waxman-Markey bill (H.R. 2454), especially in the post-2020 period as the free emission allowances are phased out for both energy producers and energy consumers. In 2030, the inflation adjusted, annual GDP level is reduced by 1.8% (or $419 billion) under the low cost scenario and by 2.4% (or $571 billion) under the high cost scenario, compared to the baseline forecast (see Table 1). To put these GDP losses in perspective, in 2008 the Federal government spent $612 billion on social security payments to retirees. Looked at another way, if GDP levels are reduced by $571 billion in 2030, Federal and State tax receipts will be approximately $170 billion lower that year since Federal

[1] The House of Representatives passed the H.R. 2454 on June 26, 2009 by a vote of 219-212.

[2] The term "NEMS/ACCF-NAM 2" is used in this report to distinguish NEMS runs conducted in this project from NEMS runs conducted by EIA, and from those conducted for ACCF and NAM last year in analyzing the Lieberman-Warner bill (S. 2191).

and State governments take approximately 30 cents out of every dollar of GDP. Thus, government budgets will be harder to meet.

Over the entire 18 year period (2012-2030) covered by ACCF-NAM analysis, cumulative GDP losses are substantial, ranging from $2.2 trillion dollars under the low cost case to $3.1 trillion under the high cost case. Again, the hit to Federal and State budgets is large, cumulative tax receipts will be reduced by between $670 billion and $930 billion compared to the baseline forecast. Given the size of projected Federal deficits and State budget receipt shortfalls, policymakers may want to think carefully before imposing the Waxman-Markey bill on the already struggling U.S. economy.

- ***Industrial production begins to decline:***

Industrial production (manufacturing, mining and electric utilities) begins to decline immediately in 2012, relative to the baseline forecast, under the Waxman-Markey bill. In 2030, U.S. industrial output levels are reduced by between 5.3 % and 6.5 % under the low and high cost scenarios. A hallmark of economic downturns and recessions is a slowdown in the growth rate or an absolute decline in the level of industrial output. Clearly, the negative impact on industrial output of the Waxman-Markey bill would make it harder to keep the U.S. economy out of recession or sluggish growth insufficient to restore job growth.

- ***Employment is negatively impacted:***

Employment is negatively impacted by Waxman-Markey, even when additional "green" jobs are factored in. Over the 2012-2030 period, total U.S. employment averages between 420,000 and 610,000 fewer jobs each year under the low and high cost scenarios than under the baseline forecast. In 2030, there are between 1,790,000 and 2,440,000 fewer jobs in the overall economy. Manufacturing employment is hard hit: by 2030 there are between 580,000 and 740,000 fewer jobs, or between a 6 and 7% reduction in total manufacturing employment in the U.S compared to the baseline forecast. On average, over the 2012-2030 period, the manufacturing sector absorbs 59 to 66% of the overall job losses caused by the Waxman-Markey bill

- ***Energy prices rise:***

Energy prices rise over the 2012-2030 period, due to the various features of the Waxman-Markey bill including prices for carbon permits which gradually rise to between $123 and $159 dollars per ton of CO_2 in 2030 as well as the renewable portfolio standards, low carbon fuel standards, and energy efficiency standards. Over the past decade, each 1% increase in GDP in the U.S. has been accompanied by a 0.3% increase in energy use, thus higher energy prices will make it harder to recover from the current recession and to reduce the current high rate of unemployment. The ACCF-NAM study shows that residential electricity prices are 5 to 8% higher by 2020, by 2030 electricity prices are between 31 to 50% higher. Gasoline prices are also higher. By 2030 prices are up to 20 to 26% higher than under the baseline forecast.

- ***Household income drops:***

Household income drops under the Waxman-Markey bill, even after accounting for rebates to consumers mandated in the bill. In 2030, the decline in annual household income ranges from about $730 in the low cost case to about $1,248 in the high cost case. However the impacts on individual states, especially in the Midwest, are about twice as high as the national average. For example, household income in Illinois is $1,096 lower by 2030 under the low cost case and $1,782 lower under the high cost case. Other Midwestern states, like Michigan, Indiana and Kansas show a similar pattern with income losses that are much higher than the national average.

Analysis of the Waxman-Markey Bill
"The American Clean Energy and Security Act of 2009" (H.R. 2454)
Using the National Energy Modeling System (NEMS/ACCF-NAM 2)

INTRODUCTION

The American Council for Capital Formation (ACCF)[3] and the National Association of Manufacturers (NAM)[4] contracted with Science Applications International Corporation (SAIC)[5] to analyze legislation introduced by Representatives Henry Waxman and Edward Markey, "The American Clean Energy and Security Act of 2009" (H.R. 2454)[6] . This study uses the NEMS/ACCF-NAM 2[7], the version used in this project of the National Energy Modeling System (NEMS) model, the model used by the U.S. Energy Information Administration (EIA) for its energy forecasting and policy analysis when asked by Congress and other federal agencies to analyze new energy and environmental policy initiatives. This study was performed by SAIC, independent of EIA.[8]

The ACCF-NAM believes it is important to fully examine the potential costs that enactment of H.R. 2454 will impose on the U.S. economy. It is becoming increasingly recognized that the cost to U.S. industries and citizens of implementing GHG emission reductions is highly dependent on the market penetration achieved by key technologies and the availability of carbon offsets by 2030. Understanding the potential economic impacts at the national, state and individual household levels can help guide choices on climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies should not be undertaken without considering their impacts on energy security, economic growth, and U.S. competitiveness. This project is designed to assist in this effort.

In addition to providing economic impacts for the U.S. as a whole, this project also provides the potential economic costs of H.R. 2454 at the state and household level for citizens and businesses in every state. Two-page reports have been prepared for each state to show the estimated cost impact of H.R. 2454 under the "High" and "Low" cost scenarios using the input assumptions provided by ACCF and NAM and the NEMS/ACCF-NAM 2 outputs for different census regions in the country.[9] A summary of the national results are provided in Table 3 and those for every state are included in Table 5 through 10.

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[3] The American Council for Capital Formation (ACCF) (www.accf.org) is a nonprofit, nonpartisan organization dedicated to the advocacy of tax and environmental policies that encourage saving and investment. The ACCF was founded in 1973 and is supported by the voluntary contributions of corporations, associations, foundations, and individuals. The mission of the ACCF is to promote economic growth through sound tax, environmental, and trade policies.

[4] The National Association of Manufacturers (NAM) is the nation's largest industrial trade association, representing small and large manufacturers in every industrial sector and in all 50 states. Headquartered in Washington, D.C., the NAM has 11 additional offices across the country. Visit the NAM's award-winning web site at www.nam.org for more information about manufacturing and the economy.

[5] SAIC is a FORTUNE 500® scientific, engineering and technology applications company that uses its deep domain knowledge to solve problems of vital importance to the nation and the world, in national security, energy and the environment, critical infrastructure, and health.

[6] The House of Representatives passed the H.R. 2454 on June 26, 2009 by a vote of 219-212.

[7] As noted, the term "NEMS/ACCF-NAM 2" is used in this report to distinguish NEMS runs conducted in this project from NEMS runs conducted by EIA, and from those conducted for ACCF and NAM last year in analyzing the Lieberman-Warner bill (S. 2191).

[8] SAIC is a policy-neutral organization. SAIC executed the NEMS/ACCF-NAM 2 model in this project using SAIC's and ACCF-NAM's interpretation of the bill, and input assumptions provided by ACCF-NAM. The modeling was performed independent of EIA. Analysis provided in this report is based on the output from the NEMS/ACCF-NAM 2 model as a result of the ACCF-NAM input assumptions. The input assumptions, opinions and recommendations in this report are those of ACCF and NAM, and do not necessarily represent SAIC views.

[9] Costs are measured as impact on GDP

The ACCF-NAM Analysis Complements the EIA Analysis of H.R. 2454

As ACCF-NAM completed analysis using the NEMS/ACCF-NAM 2 model version, EIA released its analysis of the Waxman-Markey bill.[10] ACCF and NAM believe the analysis provided in this report supplements - - rather than competes with - - analysis provided by the EIA report and, taken together, will provide policymakers a range of insights into the potential impacts of the Waxman-Markey bill.

EIA's analysis includes six "Main Analysis Cases" (the ACESA Basic Case and five alternative cases), and five "Additional Analysis Cases". Each of the ten alternative/additional cases is "similar to the ACESA Basic Case," but contains one discrete alternative assumption with the exception of the No International/Limited Case which contains two. By using a singular variable in each case (except for the two-variable case), EIA provides policymakers extensive insights into the isolated, particular impact of each assumption.

EIA states that it "cannot attach probabilities to the individual policy cases".[11] EIA does not project the "likely" level that each variable will attain by key dates. Rather, for analytical insight purposes, EIA severely restricts/enhances - - including "zero" and "maximized" - - key variables such as international offsets, low-and-no-carbon generation technologies and banking technologies while holding the other key variables in the Basic Case constant.[12] Likewise, EIA does not project the potential for the variables to occur in multiple combinations (with the exception of the No International/Limited Case which combines two variables).

The ACCF-NAM analysis complements and analytically extends the EIA analyses. Just as reason would indicate, as EIA states,[13] that the extreme case scenarios in EIA's analysis are not likely to occur, it is equally reasonable that it is unlikely for any of the eleven cases to happen without the presence of some component of at least one, and probably two or more, of the others, and that they will occur at a level at something other than zero or 100%. The ACCF-NAM analysis offers policymakers the benefit of analyzing different combinations, and different levels, of the variables identified by EIA. It is important to note that EIA's "No International/Limited Case" which, of the EIA cases, is the most similar in assumptions to the ACCF-NAM 2 about the availability of new technologies, offsets, etc shows an almost identical impact on GDP in 2030: A 2.3% reduction compared to the ACCF-NAM 2's 1.8% to 2.4% decrease.

The ACCF-NAM analysis employs two sets of input assumptions - - High and Low Cost scenarios - - for the NEMS/ACCF-NAM 2 model reflecting ACCF's and NAM's views on the variability and likely potential availability of emission reduction technologies, new energy sources and carbon offsets throughout the 2012-2030 period. The use of alternative assumptions in this project is intended to assist consideration and preparation for a range of potential results. This is offered as an attempt to project in ACCF's and NAM's view a "realistic" snapshot of the combined impacts of the likely availability/timing and level of use of emissions reduction technologies, new energy sources and offsets - - the primary "uncertainties" associated with cap-and-trade GHG reduction legislation.

[10] Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009," August 2009

[11] Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009," August 2009, page 7

[12] For analytical purposes, but not projections, EIA does provide specific levels in the ACESA High Cost Case, High Tech Case, Low Discount Case, 35CAFE2016 Case, and High Banking Case.

[13] Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009," August 2009, page 7

METHODOLOGY: USING NEMS/ACCF-NAM 2

NEMS Model

NEMS is a publicly available, national, economy-wide, integrated energy model that analyzes energy supply, conversion, and demand. It is used by EIA to provide U.S. energy market forecasts through 2030 in its flagship publication, the *Annual Energy Outlook (AEO)*. NEMS is also the principal energy policy analysis tool used by EIA to report to Congress regarding the projected impact on U.S. energy markets and the economy of GHG policies in proposed legislation. SAIC is a leading consultant to EIA on the design and implementation of NEMS, and has over 120 staff years supporting the model. The diagram below shows the 12 energy industry sectors/sub-modules modeled by NEMS.

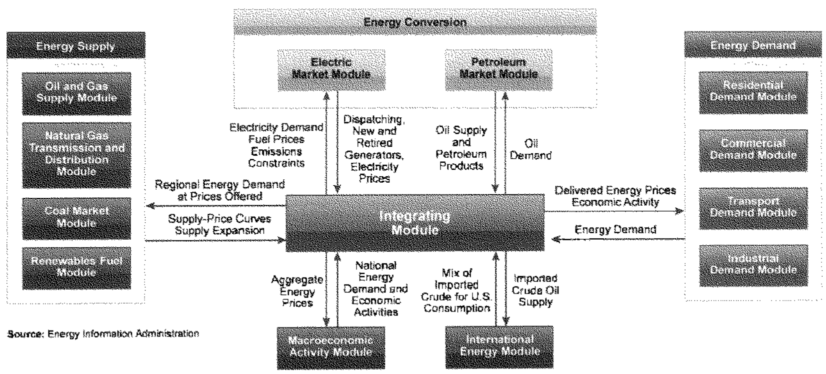

Figure 1: National Energy Modeling System

The model is the most robust model of the U.S. economy for energy forecasting, producing a general equilibrium solution for energy supply and demand in the U.S. energy markets on an annual basis. It projects the production, imports, conversion, consumption, and prices of energy, subject to a variety of assumptions that encompass macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, technology characteristics, and demographics.

NEMS provides a common analytical tool for gaining valuable insights into the likely implications of alternative GHG reduction policy options. Using the model relied on by Congress also ensures that the discussion will focus on the merits of assumptions and policy choices rather than methodology. In the end, the use of the ACCF-NAM version of NEMS in this study supports and supplements congressional consideration of alternatives and enhances opportunities to identify commonalities, strengthen the legislation, and find solution paths.[14]

[14] Two additional key information items on the operation of the NEMS model are included at Appendix 1 regarding: (1) How the model accounts for supply-side energy conversion efficiency; and, (2) Sensitivity of the model to supply-side technology capital costs for power generation.

The Importance of Assumptions Used In the Modeling

NEMS results and NEMS/ACCF-NAM 2 results are dependent on model input assumptions related to technology, cost, performance, and a variety of other factors. EIA generally performs NEMS runs using its own assumptions, and those consistent with current government laws and regulations as specified in the *AEO*, as well as assumptions included in congressional or federal agencies' requests. As with any forecast, the assumptions are the best judgment of the requestor or EIA staff, but may not necessarily be the same assumptions that would be used by others. As noted above, and further discussed below, EIA in its analysis of H.R. 2454 emphasizes the importance of assumptions, in particular the two "major uncertainties" - - the availability and use of low-and-no-carbon generation technologies and the use of offsets.

ACCF and NAM also want to emphasize the importance of the input assumptions relative to the results provided by modeling. Providing results using alternative sets of assumptions is the centerpiece - - indeed the purpose - - of this study. Applying alternative input assumptions through NEMS/ACCF-NAM 2 provides insights on implications of a range of possible outcomes that may occur as the economy adjusts to mandatory carbon constraints under provisions of H.R. 2454. The desire is to enhance understanding and analysis.

It is important to note that the ACCF-NAM version of NEMS may also use different modeling methods than other organizations, such as EIA, to represent provisions of the Waxman-Markey legislation. These can also represent a source of differences in results, in addition to model input assumptions associated with technology and offsets availability,

THE WAXMAN-MARKEY BILL (H.R. 2454)

The Waxman-Markey bill includes four titles:

- ***Title I – Clean Energy:*** Promotes renewable sources of energy and carbon capture and sequestration technologies, low-carbon transportation fuels, clean electric vehicles, and the smart grid and electricity transmission. In particular for purposes of this study, electric utilities must use electricity generated from renewable sources and energy efficiency savings, in combination, to satisfy 6% of their total load in 2012, incrementally increasing to 20% in 2020-2039.
- ***Title II – Energy Efficiency:*** Increases energy efficiency across all sectors of the economy, including buildings, lighting and appliances, transportation and industry.
- ***Title III – Reducing Global Warming:*** Places limits on heat-trapping pollutants. This is the primary title analyzed in this study and is described in greater detail below.
- ***Title IV – Transition to a Clean Energy Economy:*** Provides rebates intended to mitigate the adverse economic effects of Title III, protects U.S. consumers and industry and promotes green jobs during the transition to a clean energy economy.
- ***Title V – Agriculture and Forestry Related Offsets:*** Establishes an offset credit program from domestic agricultural and forestry sources and an advisory committee at USDA.

Title III is the primary title examined under this study. Components of Title I and Title II were included in the modeling (with some exceptions). Titles IV and V were not modeled.

Title III – Reducing Global Warming

Key provisions of the "global warming" title include:

1. ***Emission caps:*** GHG emission targets decline each calendar year according to the following schedule:

- **2012:** 4,627 MtCO2e (97% of 2005 emissions levels, or 3% below)
- **2020:** 5,056 MtCO2e (83% of 2005 emissions levels, or 17% below)
- **2030:** 3,533 MtCO2e (58% of 2005 emissions levels, or 42% below)
- **2050:** 1,035 MtCO2e (17% of 2005 emissions levels , or 83% below)

Regulated entities will have a number of options for achieving CO_2 emissions reductions, including zero CO_2 emitting technologies such as nuclear or wind generation, new technologies such as carbon capture and sequestration (CCS), carbon offset projects that reduce CO_2 emissions by an amount equivalent to that emitted, or purchasing CO_2 emissions permits on a tradable market. Emission allowances may be banked or borrowed. H.R. 2454 allows companies to invest in carbon offset projects or to purchase CO_2 emissions up to 30% of the targeted emissions (15% from domestic sources; another 15% from international sources). Consequently, it would be possible for the economy to generate 30% more emissions than targeted by H.R. 2454 as long as such emissions are offset by carbon reduction in non-covered domestic sources and international sources.

2. ***Covered Sources:*** Table 1 lists the covered sectors and a staggered initial compliance year:

STAGGERED INITIAL COMPLIANCE YEARS FOR COVERED SOURCES		
SECTOR	**POINT OF REGULATION**	**INITIAL COMPLIANCE YEAR**
Electricity	Downstream (power plants)	2012
Transportation/ Industrial	Mid/Upstream for producers and importers of petroleum-based liquid fuel, petroleum coke, or natural gas liquid	2012
Industrial	Mid/Upstream for producers and importers of specific GHGs (fossil fuel based carbon dioxide; nitrous oxide; perfluorocarbons; sulfur hexafluoride)	2012
Industrial	Downstream for specific industrial sectors (e.g., cement, primary aluminum production, ammonia manufacturing, hydrochloro-fluorocarbons production)	2012
Industrial	Downstream for chemical or petrochemical sector	2014
Industrial	Downstream for specific sectors (e.g., ethanol production, food processing, glass production, iron and steel production, pulp and paper, etc.)	2014
Industrial	Downstream for fossil fuel-fired combustion devices not covered under other sectors	
Commercial/ Residential	Midstream (natural gas local distribution companies)	2014
Other	Any geological sequestration site	2012

Table 1. COVERED SOURCES AND COMPLIANCE YEARS

Disposition of Allowances: Allowance allocations can be classified for modeling into four major categories by purpose:

- Consumer Protection (53% of total cumulative emission allowances from 2012-2030)
  - Electricity consumers (accounting for 31% of total cumulative allowances from 2012-2030)
  - Natural gas consumers (accounting for 5.7%)
  - Home heating oil and propane users (accounting for 1%)

- Low-and Moderate-Income Households (accounting for 15%)
- Transition Assistance for Industry (13% from 2012-2030)
- Energy Efficiency and Clean Energy Technology (12% from 2012-2030)
- Other Public Purposes (13% from 2012-2030)

3. ***Banking and Borrowing*:** Banking of allowances is unlimited in H.R. 2454. A two-year compliance period allows borrowing one year ahead without penalty. Borrowing allowances from years two through five can be done but with an interest rate penalty.
4. ***Strategic Reserve:*** Additional allowances, borrowed from future years, are made available for auction at a specified price. This "strategic reserve" is intended to maintain the integrity of the cumulative multi-year cap and provide some near-term price certainty.
5. ***Offsets:*** Offsets are limited to 2,000 billion tons per year - - approximately 30% of the total emissions cap. Offsets are to be evenly split between domestic and international offsets, although EPA can allow up to 1.5 billion tons if EPA projects that less than 900 million tons will be available from domestic sources at the prevailing allowance price levels. The bill establishes an Offset Integrity Advisory Board and an Offset Registry, and administrative management and verification provisions with particular stringency for international offsets. Within the total offsets allowed, USDA is authorized to issue offsets for a range of agricultural projects.

MODELING METHODOLOGY AND INPUT ASSUMPTIONS

A variety of assumptions were required for the purposes of completing modeling for this study. Some of these are summarized below, with a more detailed description provided in Appendix 2.

The AEO2009

The ACCF-NAM analysis of the Waxman-Markey bill uses the most recent version of the EIA *Annual Energy Outlook*, the April *AEO2009*. This is the third version of the *AEO* released by EIA for 2009. The April *AEO2009* includes the Stimulus Law enacted in February 2009, the American Recovery and Reinvestment Act of 2009 (ARRA), as well as the original Stimulus Law enacted in October 2008, the Energy Improvement and Extension Act of 2008. It also includes a new macroeconomic outlook that took into account the impact of the significant worsening of the ongoing recession that was not included in the earlier versions of the *AEO2009*.

In the near term, ARRA is projected to decrease the magnitude and duration of the current recession. Further out in the projection period, however, ARRA adversely affects macroeconomic performance as the larger budget deficits that result from the additional spending embedded in the stimulus package cause interest rates to be higher and GDP growth to be lower. NEMS model changes reflect the following programs of ARRA 2009: Weatherization, assisted housing, energy efficiency, and conservation block grants; State energy programs; Plug in hybrid and electric vehicle tax credits; Tax credits for renewables; Loan guarantees for renewables, biofuels and transmission projects; Support for CCS; and, Smart grid expenditures[15]

Alternative Technology and Implementation Input Assumptions Used in the Analysis

The ACCF-NAM believe there is legitimate uncertainty regarding whether the emissions reduction technologies (carbon capture and sequestration), new energy sources (renewables) and market mechanisms (carbon offsets) anticipated for achieving GHG emission reductions will be fully available

[15] The details of the implementation are described in, "*An Updated Annual Energy Outlook 2009 Reference Case Revisions Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in Economic Outlook,*" April 2009, Energy Information administration.

and utilized in the period analyzed (2012 – 2030). While they will likely make some level of contribution to meeting GHG limits, the ACCF-NAM believe that, for a variety of reasons including limitations in technology advancements, societal concerns and regulatory requirements, it is unlikely that they will make the full level of contribution required to achieve emissions reduction targets in H.R. 2454 by 2030.

The "uncertainties" regarding the availability and application of CCS technologies, nuclear and renewables for electric generation, and domestic and international offsets are now well recognized in considering the potential impact of GHG legislation. Other variables such as banking, borrowing and allowance price limitations also have required assumptions for modeling analysis.

As in its previous analyses of S. 280 and S. 2191, EIA in its analysis of H.R. 2454 emphasizes the importance of assumptions, in particular the two "major uncertainties" - - (1) "the timing, cost and public acceptance of low-and-no-carbon baseload electricity technologies . . . nuclear power and fossil (coal and natural gas) with CCS"; and, (2) "offset use . . . is an open question". In particular, EIA states:

> **"Beyond the usual uncertainties related to the technical, economic and market supply of offsets, the future use of offsets for ACESA compliance also depends both on regulatory decisions that are yet to be made by the EPA, on timing and scope of negotiations on international agreements or arrangements between the United States and countries where offset opportunities may exist, and on emissions reduction commitments made by other countries."** [16]

Accordingly, for executing NEMS/ACCF-NAM 2 model runs in this project,[17] the ACCF-NAM provided assumptions regarding the likely availability and application of these technologies, energy sources and offsets in the period of 2012 to 2030. The model runs were executed under two scenarios established by ACCF-NAM - - *High Cost* and *Low Cost* scenarios to allow examination of the effects of different levels of availability/application of these items.[18] The runs under these scenarios used model input assumptions provided by ACCF-NAM on the following items:

- Cap on new advanced nuclear generation capacity added during the projection period;
- Cap on sequestered advanced coal-fired generation capacity (IGCC/CCS) added during the projection period;
- Cap on sequestered advanced natural gas-fired generation capacity (NGCC/CCS) added during the projection period;
- Caps on biomass and wind powered generation capacity added during the projection period;
- Limitation on the availability and use of domestic and international offsets;
- Limitation on the use of banking; and
- Limitations on annual growth of allowance prices.

The base assumptions retained the power generation technology overnight capital costs and operating and maintenance (O&M) costs and World Oil Price Profile assumed for the *AEO2009* Reference Case. The analysis did not consider a strategic reserve. Table 2 below provides an overview of the scenario specifications used in the ACCF-NAM analysis.

[16] Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009", August 2009, page vii.

[17] As noted above, the term "NEMS/ACCF-NAM 2" is used in this report to distinguish NEMS runs conducted in this project from NEMS runs conducted by EIA, and from those conducted for ACCF and NAM last year in analyzing the Lieberman-Warner bill (S. 2191).

[18] Costs scenarios reflect the impact on GDP.

Table 2. ACCF-NAM SCENARIO SPECIFICATIONS

	CASE #1 High Cost Scenario	CASE #2 Low Cost Scenario
NEW TECHNOLOGY CAPACITY CONSTRAINTS (2030 Build Limits)		
NUCLEAR[a]	10 GW	25 GW
IGCC with CCS (2020 start year)	15 GW	30 GW
Biomass	Max 3 GW/year	Max 5 GW/year
Wind (onshore)	Max 5 GW/year	Max 10 GW/year
NGCC with CCS (2020 start year)	15 GW	30 GW
TECHNOLOGY OVERNIGHT CAPITAL COST[b] (2009 $/kW)		
All Capital Costs	AEO2009 BASIS	AEO2009 BASIS
Advanced Pulverized Coal	1985	1985
Advanced IGCC	2294	2294
Advanced IGCC with CCS	3273	3273
Advanced NGCC	985	985
Advanced NGCC with CCS	1736	1736
Advanced Nuclear	2964	2964
Advanced Combustion Turbine	623	623
Onshore Wind	1855	1855
Offshore Wind	2609	2609
Photovoltaic	4391	4391
Solar Thermal – Concentrating	4843	4843
Hydropower - Large	1708	1708
Biomass Combined Cycle	3446	3446
Geothermal	2882	2882
OTHER KEY MODELING ASSUMPTIONS		
Projected Crude Oil Price Profile	AEO2009 BASIS	AEO2009 BASIS
Allowance Price Ceiling (cap on annual increase)	10% Max	10% Max
H.R. 2454 ASSUMPTIONS		
Offsets	1,000 MMT Limit (Split 95% Domestic and 5% International)	1,000 MMT Limit (Split 95% Domestic and 5% International)
Banking	5,000 MMT	5,000 MMT
Strategic Reserve	Modeled Indirectly	Modeled Indirectly
Title I Combined Efficiency/ Renewable Electricity Standard	Modeled – See Appendix 2	Modeled – See Appendix 2
Title II Energy Efficiency	Modeled – See Appendix 2	Modeled – See Appendix 2
Title III Cap and Trade Provisions	Modeled – See Appendix 2	Modeled – See Appendix 2
Title IV – Transition to a Clean Energy Economy	Not Modeled	Not Modeled

a Net added capacity; accounts for 3.4GW uprates to existing plants and 4.4 GW of retirements.

b Overnight cost does not account for the following factors: 1) Location and elevation; 2) Contingency; 3) Interest during construction; Optimism and learning. The model accounts for these factors for the purposes of capacity addition.

Discussion of Key Input and Methodology Assumptions

Title I – Clean Energy: Subtitle A – Combined Efficiency and Renewable Electricity Standard

Section 101 of the Bill requires electric utilities that sell more than 4 million MWh of electricity to consumers to meet a specified percentage of electricity generated from renewable sources and energy efficiency savings. The bill sets up a profile to ultimately achieve a combined *Efficiency and Renewable Electricity Standard* with a goal of 15% renewables and 5% energy efficiency by 2020. Inputs to the Electricity Market Module and Residential/Commercial/Industrial Demand Modules were adjusted to approximate the goal. As stipulated in H.R. 2454, nuclear generation was excluded from the base in calculating the required annual percentages.

Title II – Energy Efficiency

The various provisions of Title II provide impetus for energy efficiency improvements for buildings, lighting and appliances, transportation, and industries. While some provisions of this Title are specific, others are not. In order to model the implications of energy efficiency improvements in its entirety, SAIC incorporated the assumptions of the EIA high technology side-cases for the residential, commercial and transportation sectors. The high technology case assumes that more energy consuming technologies are available for consumers earlier, at a lower cost and higher levels of energy efficiency.

Title III CO_2 Emissions Target

Overall CO_2 emissions from energy production and consumption from entities covered under H.R. 2454 grow in the EIA's Reference Case to approximately 6,200 million metric tons (MMT) CO_2 by 2030 (see green line in Figure 2); targets proposed under H.R. 2454 would constrain emissions to a path shown as the descending blue and orange line in Figure 2. Based on analysis of H.R. 2454, emissions would need to be cut to 4,627 $MMTCO_2$ by 2012, to 5,056 $MMTCO_2$ by 2020, and to 3,533 $MMTCO_2$ by 2030.

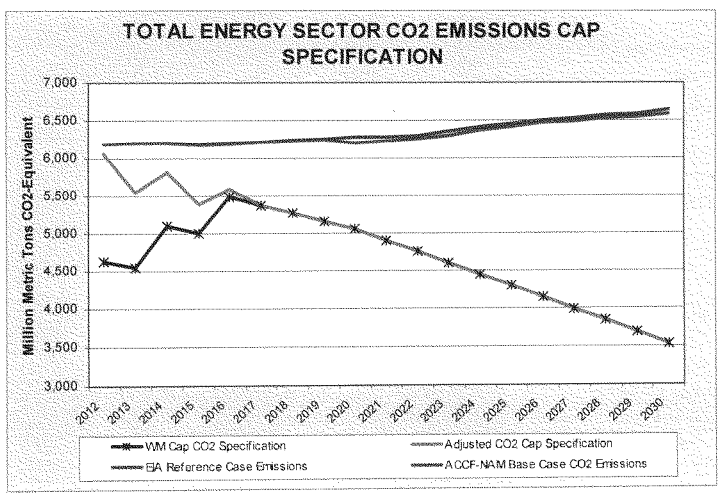

Figure 2. Specification of CO_2 Emissions Cap and Adjusted Cap Compared to EIA Reference Case Emissions and ACCF-NAM Base Case Emissions

The adjusted cap specification (orange curve) represents value adjustments to reflect the staggered initial compliance years based on the proportion of actual covered emission sources; the Waxman-Markey bill phases in coverage from 66.2% in 2012, 75.7% in 2014, and 84.5% in 2016. In order to implement this coverage requirement, some technical adjustments were made in the cap for the early years (2012 - 2016). Figure 2 also presents the ACCF-NAM Base Case emissions projection that is discussed later.

Offsets

ACCF and NAM do not believe that the full 30% (2,000 MMT per year) in offsets authorized will be achieved. Rather, ACCF and NAM believe the more likely level of offsets actually available and utilized will be approximately 15% (1,000 MMT per year) of covered CO_2 emissions. Other organizations have questioned the degree to which both domestic and international offsets will be available and how verifiable the reductions will be. For example, a 2008 report by the GAO analyzing the use of offsets by EU countries striving to meet their Kyoto Protocol targets noted that many of the emissions reductions for which companies claimed credit would have occurred anyway and that verifying international emission reductions is a difficult and slow process with a significant potential for fraud (see http://www.gao.gov/new.items/d09151.pdf for details). The offset supply and cost data used for this analysis are those used for the recent EIA analysis of S. 2191 (Lieberman-Warner Climate Security Act of 2007). International marginal abatement curves were adjusted to approximate the requirement for 1.25 tons of offsets credits for each ton of emissions being offset.

Allowance Banking

ACCF and NAM considered the level of allowance *banking* that should be applied in the analysis of H.R. 2454 and decided upon a cumulative level of 5,000 MMT by 2030. While application of higher levels of banking could be justified given the construction of the Waxman-Markey bill providing free auctions through 2025, in ACCF - NAM's judgment, the 5,000 MMT level would be the most likely level achieved in the use of banking under H.R. 2454. Note that while allowance *borrowing* from the future is allowed, it was not implemented.

Strategic Reserve Allowance Price Ceiling

While the modeling did not directly account for a Strategic Reserve of allowances, we believe its main purpose is to control allowance price volatility. NEMS has a way to control allowance price movement; allowance prices can be set to escalate at a rate no higher than a specified percentage level per year, in real terms, during intervals when allowance balances are held. In its analysis of H.R. 2454, EIA imposed a ceiling of 7.4% annual increase in allowance prices.[19] In the ACCF-NAM analysis of H.R. 2454, the ceiling is increased to 10%. The reasoning for the higher rate of increase in the ACCF-NAM analysis is that if the technology to reduce GHGs through CCS at coal and natural gas fired electric utilities or a large scale increase in nuclear generation for electricity or renewables is not commercially available over the next 10 to 20 years, companies will have no choice but to pay the market price for each ton of CO_2-equivalent they emit.

Allowance Allocations and Auction Revenue Calculation and Distribution

The methodology used to implement allowance allocations and revenue distribution in NEMS/ACCF-NAM 2 made use of the basic model structure that was previously set up to implement prior cap and trade legislation, such as S. 2191. The Waxman-Markey bill allowance distribution specifications were appropriately mapped to existing allocation categories, where available. Of the various groups identified for consumer protection and transitional assistance, SAIC modeled the allocation of allowances to:

[19] Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009," August 2009, page 55.

- Electricity consumers (accounting for 31% of total cumulative allowances from 2012-2030)
- Natural gas consumers (accounting for 5.7% of total cumulative allowances)
- Home heating oil and propane users (accounting for 1% of total cumulative allowances)
- Low-and Moderate-Income Households (accounting for 15% of total cumulative allowance)

Allocation of auction revenues was modeled by funding the following categories of macroeconomic expenditures:

- Real federal non-Medicaid grants to state & local governments
- Real federal non-defined consumption except depreciation & personnel
- Real state & local consumption except capital construction & personnel
- State and local government transfer receipts
- Other federal government transfers to rest of the world
- Federal taxes on production and imports other than for a VAT
- State and local government transfer receipts
- Non-Medicare and Social Security full-employment federal transfer payments
- State & local non-medical transfer payments

Auction revenues from unallocated allowances were directed to general government revenues in order to retain budget neutrality. Allowance allocation to trade-vulnerable industries was not modeled.

Title IV – Transition to a Clean Energy Economy

SAIC did not model any provisions in Title IV.

ACCF-NAM Base Case

A project-specific "ACCF-NAM Base Case" was developed for purposes of modeling this project; the ACCF-NAM Base Case is compared to the *AEO2009* Reference Case in Figure 2. The ACCF-NAM Base Case was developed by applying assumptions based on the best judgment of ACCF and NAM regarding the likely availability/timing of emissions reduction technologies and new energy sources and the level of their use by 2030 as alternative input assumptions to those contained in the *AEO2009* Reference Case. Including these alternative assumptions on technologies and energy sources in the Base Case allows the model to isolate results on the impact of the provisions of H.R. 2454. This provides a more definitive picture of the projected impact of the bill provisions themselves.

RESULTS OF THE ANALYSIS

Using the input assumptions and two scenarios provided by ACCF-NAM, the model runs generated results showing the economic effects of H.R. 2454 provisions at the national level and for every state. The study assumes federal preemption. The absence of federal preemption would risk higher costs.

ACCF-NAM Results at the National Level

Key Results in the ACCF-NAM Analysis of the Waxman-Markey Bill (H.R. 2454)

Table 3 below shows the results at the national level of the analysis performed under the NEMS/ACCF-NAM 2 modeling for the ACCF-NAM Base Case, Low-Cost Case, and High Cost Case. The analysis performed under the NEMS/ACCF-NAM 2 modeling, as shown in Table 3, in combination with other ACCF-NAM analysis, indicate substantial and growing impacts to consumers and the economy of meeting increasingly stringent emission targets through 2030. This study's modeling of H.R. 2454 provides the following key results and policy implications:

	Baseline (ACCF-Ref) 2020	2025	2030	Low Cost Case (WM) 2020	2025	2030	High Cost Case (WM) 2020	2025	2030
GDP (Billion 2007$)	$ 18,443	$ 21,016	$ 23,802	$ 18,403	$ 20,906	$ 23,384	$ 18,374	$ 20,853	$ 23,231
Loss in GDP (Billion 2007$)				$ 40	$ 112	$ 419	$ 68	$ 164	$ 571
% Loss				0.2%	0.5%	1.8%	0.4%	0.8%	2.4%
Employment (Millions)	157.2	160.7	165.8	157.2	160.4	164.0	157.1	160.2	163.4
Job Loss (Millions)				-0.01	0.33	1.79	0.06	0.52	2.44
% Loss				0.0%	0.2%	1.1%	0.0%	0.3%	1.5%
Industrial Output (Billion 2007$)	$ 7,962	$ 8,570	$ 8,839	$ 7,817	$ 8,306	$ 8,368	$ 7,790	$ 8,254	$ 8,263
Loss in Industrial Output (Billion 2007$)				$ 144	$ 265	$ 471	$ 172	$ 316	$ 575
% Loss				1.8%	3.1%	5.3%	2.2%	3.7%	6.5%
Coal Mining Output (Billion 2007$)	$ 27.4	$ 28.6	$ 29.2	$ 17.6	$ 12.9	$ 7.5	$ 17.0	$ 12.8	$ 7.0
Loss in Coal Mining Output (Billion 2007$)				$ 9.8	$ 15.7	$ 21.7	$ 10.4	$ 15.8	$ 22.2
% Loss				36%	55%	74%	38%	55%	76%
Primary Metals (Billion 2007$)	$ 188	$ 187	$ 164	$ 176	$ 166	$ 127	$ 171	$ 158	$ 116
Loss in Primary Metals Output (Billion 2007$)				$ 12	$ 21	$ 37	$ 17	$ 29	$ 48
% Loss				6%	11%	23%	9%	15%	29%
Carbon Allowance Price (2007 $/metric ton CO2e)				$ 47.50	$ 76.50	$ 123.21	$ 61.24	$ 98.63	$ 158.85
Average Household Income (2007$)	$ 98,929	$ 110,009	$ 121,731	$ 98,811	$ 109,670	$ 121,001	$ 98,679	$ 109,445	$ 120,483
Loss (2007$)				118	339	730	250	564	1248
% Change				-0.1%	-0.3%	-0.6%	-0.3%	-0.5%	-1.0%
Energy Expenditures (Billion 2007$)	$ 1,480	$ 1,549	$ 1,682	$ 1,538	$ 1,652	$ 1,996	$ 1,584	$ 1,728	$ 2,136
Increase(2007$)				$ 57	$ 103	$ 313	$ 104	$ 179	$ 454
% change				3.9%	6.7%	18.6%	7.0%	11.6%	27.0%
Retail gasoline prices (2007 $/gallon)	$ 3.61	$ 3.69	$ 3.85	$ 3.92	$ 4.13	$ 4.62	$ 4.01	$ 4.28	$ 4.86
% Change				8.4%	12.1%	20.0%	11.1%	16.1%	26.1%
Residential Electricity Price (2007 Cents/Kwh)	11.10	11.22	11.69	11.66	11.77	15.36	11.98	12.51	17.54
% change				5.0%	4.9%	31.4%	7.9%	11.5%	50.0%
Industrial Electricity Prices (2007 Cents/Kwh	6.45	6.57	6.91	7.26	7.78	10.30	7.84	8.68	12.17
% change				12.5%	18.4%	48.9%	21.5%	32.0%	76.0%
Residential Natural Gas Prices (2007 $/Mcf)	$ 12.88	$ 12.93	$ 14.27	$ 12.46	$ 13.55	$ 22.31	$ 12.90	$ 14.24	$ 24.75
% change				-3.3%	4.8%	56.3%	0.1%	10.1%	73.5%
Industrial Natural Gas Prices (2007 $/Mcf)	$ 7.65	$ 7.62	$ 8.85	$ 10.19	$ 12.26	$ 16.55	$ 11.56	$ 14.19	$ 18.89
% change				33.3%	61.0%	87.1%	51.1%	86.3%	113.5%
Electric Utility Coal Prices (2007 $/Ton)	$ 38	$ 39	$ 40	$ 124	$ 180	$ 269	$ 151	$ 224	$ 345
% change				224%	359%	565%	295%	472%	755%
Manufacturing Employment (Millions)	12.0	11.6	10.1	11.8	11.2	9.5	11.7	11.1	9.4
Job Loss (Millions)				0.21	0.38	0.58	0.28	0.49	0.74
% Loss				1.8%	3.3%	5.8%	2.3%	4.2%	7.3%

Table 3: Summary of Results for the United States

- ***U.S. economic growth slows:***

U.S. economic growth slows under the Waxman-Markey bill (H.R. 2454), especially in the post-2020 period as the free emission allowances are phased out for both energy producers and energy consumers. In 2030, the inflation adjusted, annual GDP level is reduced by 1.8% (or $419 billion) under the Low Cost Scenario and by 2.4% (or $571 billion) under the High Cost Scenario, compared to the Base Case forecast. To put these GDP losses in perspective, in 2008 the Federal government spent $612 billion on social security payments to retirees. Looked at another way, if GDP levels are reduced by $571 billion, Federal and State tax receipts will be approximately $170 billion lower since Federal and State governments take approximately 30 cents out of every dollar of GDP. Thus, government budgets will be harder to meet.

Over the entire 18 year period (2012-2030) covered by ACCF-NAM analysis, cumulative GDP losses are substantial, ranging from $2.2 trillion dollars under the Low Cost Case to $3.1 trillion under the High Cost Case. Again, the hit to Federal and State budgets is large; cumulative tax receipts will be reduced by between $670 billion and $930 billion compared to the Base Case forecast. Given the size of projected Federal deficits and State budget receipt shortfalls, policymakers may want to think carefully before imposing the Waxman-Markey bill on the already struggling U.S. economy.

- ***Industrial production begins to decline:***

Industrial production (manufacturing, mining and electric utilities) begins to decline immediately in 2012, relative to the baseline forecast, under the Waxman-Markey bill. In 2030, U.S. industrial output levels are reduced by between 5.3% and 6.5% under the Low and High Cost scenarios. A hallmark of economic downturns and recessions is a slowdown in the growth rate or an absolute decline in the level of industrial output. Clearly, the negative impact on industrial output of the Waxman-Markey bill would make it harder to keep the U.S. economy out of recession or sluggish growth insufficient to restore job growth.

- ***Employment is negatively impacted:***

Employment is negatively impacted by Waxman-Markey, even when additional "green" jobs are factored in. Over the 2012-2030 period, total U.S. employment averages between 420,000 and 610,000 fewer jobs each year under the Low and High Cost Scenarios than under the baseline forecast. In 2030, there are between 1,790,000 and 2,440,000 fewer jobs in the overall economy. Manufacturing employment is hard hit: by 2030; there are between 580,000 and 740,000 fewer jobs, or between a 6% and 7% reduction in total manufacturing employment in the U.S compared to the baseline forecast. On average, over the 2012-2030 period, the manufacturing sector absorbs 59 to 66% of the overall job losses caused by the Waxman-Markey bill.

- ***Energy prices rise:***

Energy prices rise over the 2012-2030 period, due to the various features of the Waxman-Markey bill including prices for carbon permits which gradually rise to between $123 and $159 dollars per ton of CO_2 by 2030 as well as the renewable portfolio standards, low carbon fuel standards, and energy efficiency standards. Over the past decade, each 1% increase in GDP in the U.S. has been accompanied by a 0.3% increase in energy use, thus higher energy prices will make it harder to recover from the current recession and to reduce the current high rate of unemployment. The ACCF-NAM study shows that residential electricity prices are 5 to 8% higher in 2020, in 2030 electricity prices are between 31 to 50% higher. Gasoline prices also rise; in 2030 prices are up to 20 to 26 % higher than under the baseline forecast.

- ***Household income drops:***

Household income drops under the Waxman-Markey bill, even after accounting for rebates to consumers mandated in the bill. In 2030, the decline in annual household income ranges from about $730 in the low cost case to about $1248 in the high cost case. However the impacts on individual states, especially in the Midwest, are about twice as high as the national average. For example, household income in Illinois is $1,096 lower in 2030 under the low cost case and $1,782 lower under the high cost case. Other Midwestern states like Michigan, Indiana and Kansas show a similar pattern, and income losses are much higher than the national average.

Other Significant Results

CO2 Emissions

Key Finding: *Given the two alternative sets of assumptions used for this study and an allowance banking specification of 5000 MMT CO_2 in 2030, Figure 3 shows the respective alternative pathways to achieving the CO_2 emissions cap. The cap is exceeded during much of the projection to meet banking requirements.*

Due to the banking requirement, the model exceeds the cap and over-controls during much of the projection period, borrowing from the bank over the last several years to approximately meet the 2030 cap value; note that the convergence tolerance limits in 2030 allow for slight variation from the cap value.

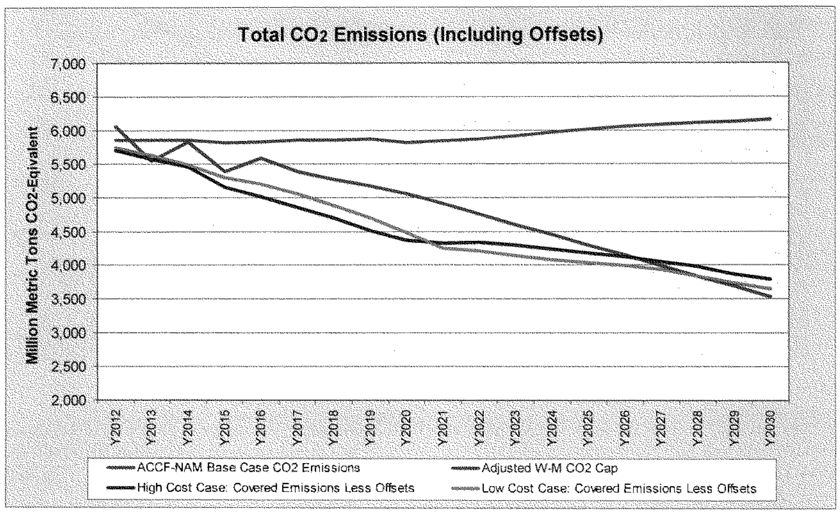

Figure 3. Comparison of Low and High Cost CO_2 Emissions Projections (Less Offsets) with ACCF-NAM Reference Case and Adjusted W-M Cap

CO2 Allowance Prices

Key Finding: *Given two alternative sets of assumptions used for this study and a 10% annual allowance price cap, the model projects allowance cost profiles that would be required to meet the emissions goals established by H.R. 2454 plus the banking requirements. While the two cases differ, with the Low Cost Case being price-displaced by 1 to 3 years further into the future, both ultimately call for high price levels to satisfy the emissions cap profile. The 2020 levels range from \$48/ton (Low Cost Scenario) to \$61/ton (High Cost Scenario). Due to offset availability limits, the 2030 levels are significantly higher -- ranging from \$123/ton (Low Cost case) to \$159/ton (High Cost case).* For both cases, the 10% annual allowance growth limit was reached in all years of the projection.

Based on the particular set of generation sources and technology market penetration constraints that the ACCF-NAM cases impose, and the cost and constrained availability of offsets, the NEMS/ACCF-NAM 2 model derives the CO_2 allowance cost profile required to achieve the H.R. 2454 emissions goals to 2030, also accounting for banking specifications. This cost profile is calculated so as to adjust fossil fuel prices to the extent needed by the model to add and dispatch an annual inventory of technologies required to at least meet the emissions goal profile, accounting for offsets purchases.

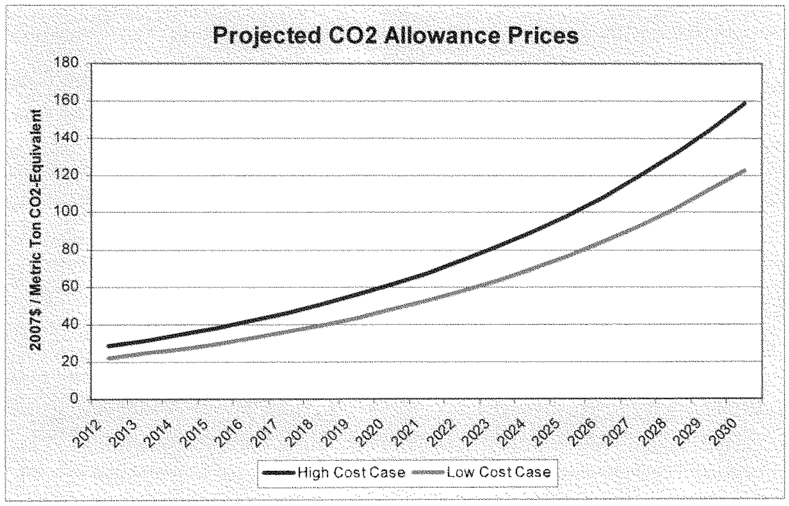

Figure 4: CO2 Allowance Price Profiles Derived by the Model

In constant 2007 dollars, the price of CO_2 allowances (what companies must pay to emit CO_2) could reach between \$48 and \$61 per metric ton of CO_2 (MT) by 2020 and could increase to between \$123/MT and \$159/MT by 2030 (see Figure 4). In both cases, free allowances and the purchase of relatively inexpensive offsets significantly constrains allowance prices until the early 2020s (more offsets being made available in the low-cost case), followed by a rapid increase in prices as offset availability levels off and the CO_2 emissions goal continues to become more restrictive. The steepest parts the price curves reflect significant retirement of conventional coal-fired power generation with replacement by more expensive advanced coal and natural gas generation technologies that capture and sequester CO_2, other gas-fired technology, nuclear power, and renewable generation technologies.

The free distribution of allowances and auctioning of allowances to emitting and non-emitting CO_2 sources will generate revenue for the government that will ultimately be spent by various government entities to cover programs designed to help businesses and consumers reduce their emissions or lessen the impacts associated with higher energy prices resulting from the allowance prices. The revenues obtained from the sale and resale of CO_2 allowances in the two ACCF-NAM cases are therefore not lost to the economy, but flow into the coffers of the selling entities (e.g., U.S. treasury or state treasuries) and are redistributed based on the bill provisions per mapping to existing policy options already set up in the model (e.g., assistance to low income consumers, building energy efficiency, transition assistance, etc.).

Impact on Jobs

Key Finding: *Based on the allowance price profiles derived for the two ACCF-NAM cases, H.R. 2454 is projected to yield significant employment loss due to the loss of revenues resulting from higher fuel and electricity costs. In 2030, job loss is projected to range from 1.8 million (Low Cost case) to 2.4 million (High Cost case) jobs/year.*

Under H.R. 2454 the U.S. economy would begin to shed approximately 500,000 jobs a year by 2025 under the high cost scenario (see Figure 5). This is primarily a result of higher carbon prices resulting in higher fuel costs for industry and higher cost to industry to comply with emissions limits. As the cap becomes more restrictive and the economy has less freedom to deal with reducing emissions, carbon prices and fuel prices increase rapidly, leading to greater job losses. In 2030, there are between 1.8 and 2.4 million fewer jobs (see Figure 5). These job losses are net of the new jobs which may be generated by increased spending on renewable energy, energy efficiency, and carbon capture and storage.

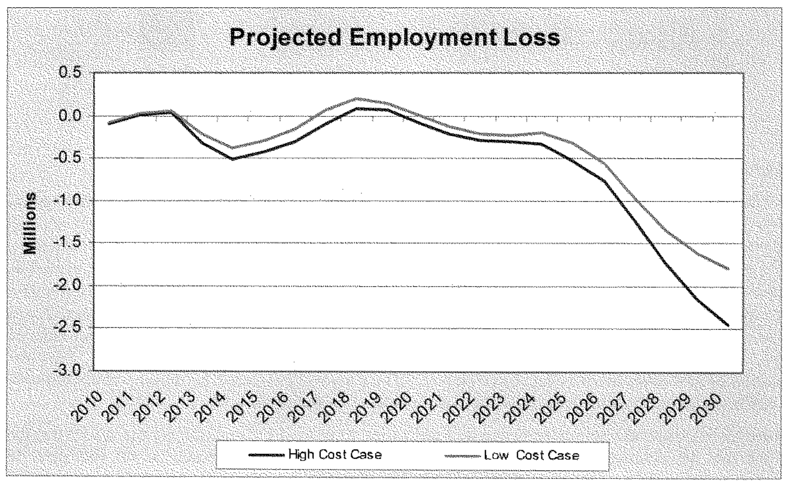

Figure 5: Employment Loss

Impact on Disposable Household Income

Key Finding: *H.R. 2454 is projected to yield significant household income loss resulting from higher payments for fuels and electricity. Although the bill provides some consumer relief for electricity and natural gas customers during the early years, higher energy prices ultimately have ripple impacts on prices throughout the economy and would impose a financial cost of $339 to $564 under the low and high cost scenarios year by 2025 on national households, rising to $564 to $1248 per household in 2030.*

Figure 6 compares household income loss for the two ACCF-NAM cases. Both income loss profiles are similar in shape as impacted by the projected allowance price profiles. For the Low Cost case, an initial decline of $118 in 2020 is followed by a steeper decline to $339 in 2025 and $730 in 2030. For the High Cost case, an initial decline of $250 is followed by larger declines to $564 in 2025 and $1,248 in 2030.

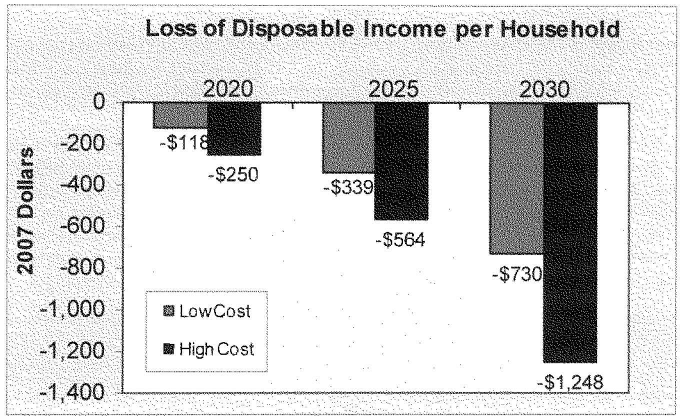

Figure 6: Household Income Loss

Impact on Energy Prices

Key Finding: *H.R. 2454 is projected to yield significant energy price increases by 2030 based primarily on the inclusion of the cost of carbon (as quantified by CO_2 allowance price profiles) as a price component for fossil fuels (based on carbon content), as well as the construction and operation of a more costly suite of energy conversion technologies that help satisfy emission limits. A revamped power generation sector is projected to increase the cost of electricity to the residential sector between 31 (Low Cost case) and 50% (High Cost case) by 2030, while the natural gas price increase is projected to range between 56 (Low Cost case) to 74% (High Cost case).* However, *effects on electricity and natural gas prices to residential and commercial consumers are substantially mitigated through 2025 by the allocation of free allowances to regulated electricity and natural gas local distribution companies. Prices rise rapidly after 2025 as the free allowances are phased out and replaced by an auction.*

In order to influence technology selection and utilization to control CO_2 emissions, the model translates a CO_2 tax into an incremental adjustment of fossil fuel prices. The tax is based on the fuel price levels required by the model to annually add and dispatch energy conversion supply technologies so as to meet annual emissions goals for covered sectors. Adjustments are made on the basis of the contribution of carbon to the total mass of a fuel; therefore, the impact on coal is much greater than natural gas. The allowance price profiles discussed previously were calculated in this manner with the resultant impacts on fuel prices shown in Figures 7 through 10.

In constant 2007 dollars, most energy prices are projected to increase under H.R. 2454, particularly coal, oil, and natural gas, directly reflecting the impact of increasing CO_2 allowance prices. The price of gasoline would increase between 8.4 to 11.1% in 2020. For example, motorists would pay an additional $0.31 to $0.40 per gallon by 2020 (see Figure 7). In addition, U.S. residential consumers would see electricity prices rise between 31 and 50% by 2030 (see Figure 8); prices remain relatively flat during part of the projection due to consumer protection measures. The residential natural gas price increase is projected to range between 56 to 74% (see Figure 10) in 2030; prices remain relatively flat during part of the projection due to the provision that provides free allocations to local gas distribution companies and partial rebates to gas customers. Prices rise rapidly after the free allocations phase out.

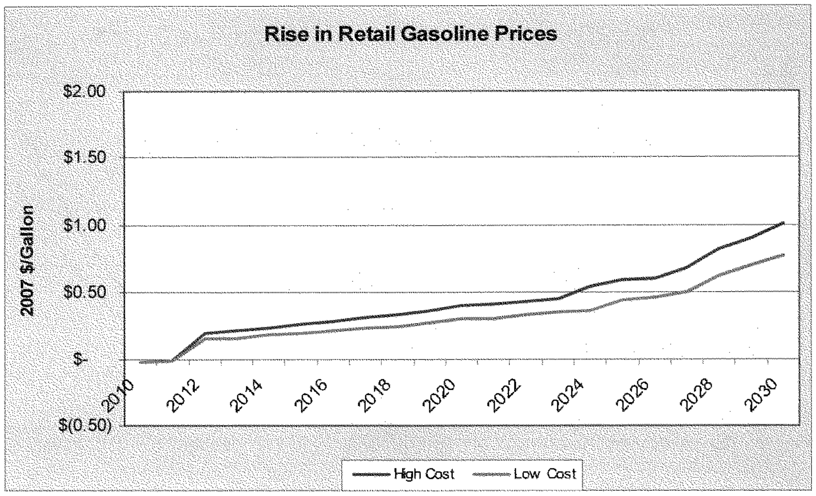

Figure 7: Retail Gasoline Price Increase

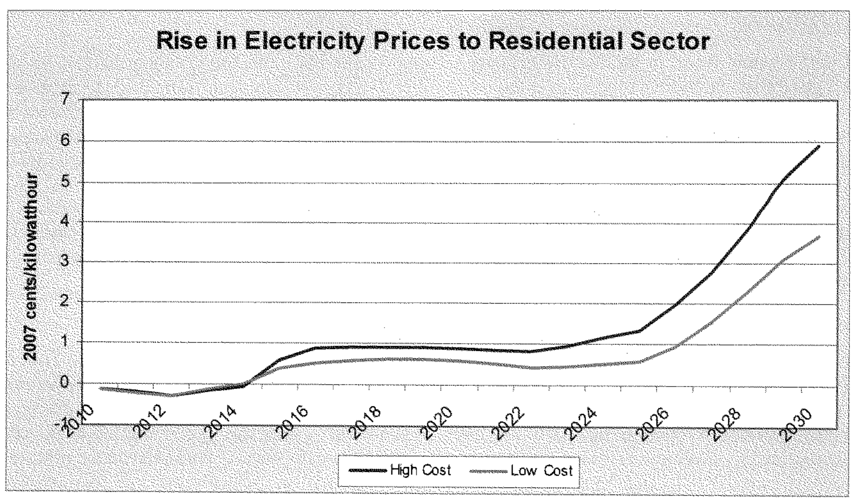

Figure 8: Residential Electricity Price Increase

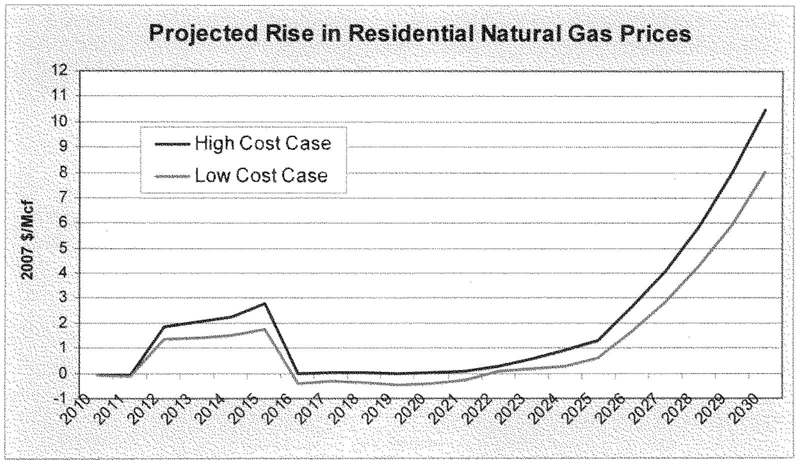

Figure 9: Residential Natural Gas Price Increase

Factors Contributing to Higher Electricity Prices

Key Finding: *H.R. 2454 would reduce GHG emissions from all sectors of the economy (transportation, residential, commercial, and industry); however, as the largest emitter of GHGs, the primary impact would fall on the electricity generation sector.*

H.R. 2454 would result in the electric industry retiring (or possibly retrofitting) about half of the coal-based generation in combination with using more expensive, as yet unproven technology to capture and store CO_2 in geologic repositories. Coal-based power generation is projected to decline by almost 77% between 2012 and 2030. Natural gas fares much better and is projected to continue to maintain capacity levels, increasing generation output from 58% to 77% between 2012 and 2030 (Low Cost and High Cost cases); while natural gas generation increases market share relative to coal to help meet the CO_2 cap, the increased cost of natural gas by the end of the projection is a key factor contributing to the higher electricity prices. To meet the stringent goals of H.R. 2454, the electric industry would also have to add and substitute higher cost technologies, such as biomass and wind, for historically cheaper fossil generation. This is true in both the Low and High Cost cases.

Impact on Total Energy Expenditures

Key Finding: *By 2030, gross US energy expenditures are projected to increase 19% in the Low Cost case and 27% in the High Cost case over the ACCF-NAM Base case. These significant increases reflect the impacts of increased fuel costs (primarily resulting from CO_2 allowance prices) and changes to energy conversion technology infrastructure costs. While these results may not reflect all of the direct redistribution of allowance revenues back to these sectors, they do include consumer price rebates for electricity, natural gas, and home heating oil purchases based on partial return of free allowance allocations, as well as impacts of demand-side energy efficiency improvements projected by the model.*

Figure 10 presents the ACCF-NAM model results for the total non-renewable US energy expenditures for the residential, commercial, and industrial sectors, plus the renewable and non-renewable expenditures for the transportation sector. The High and Low Cost cases are compared with the ACCF-NAM baseline; inherent in these results is the inclusion of the CO_2 allowance price impacts on fuel costs. Starting in 2012, increases are projected to range from 3% for the Low Cost case to 5% for the High Cost case. By 2020, this range becomes 4% to 7%, and the projected results for 2030 range from 19% to 27%. These expenditures include rate amelioration for residential and commercial natural gas and electricity customers during the projection period, as well as reduced energy consumption resulting from implementation of higher efficiency equipment and appliances.

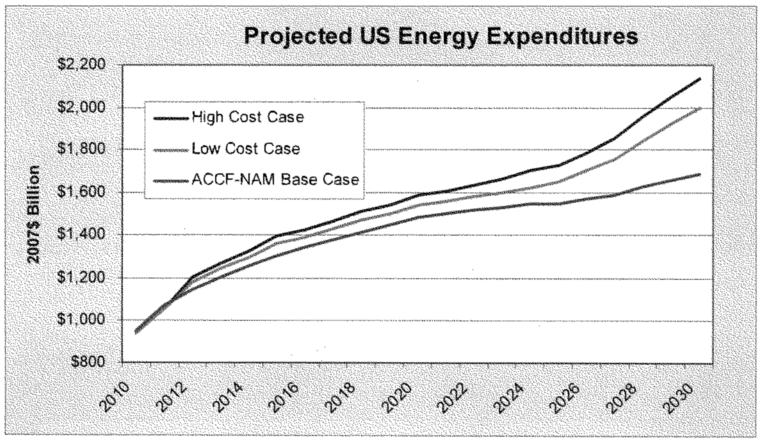

Figure 10: Increase in U.S. Energy Expenditures

Utility Electricity Generation by Fuel Type

Key Finding: *Constraints on nuclear, fossil with sequestration, and renewables generation capacity growth (see* Table 2*: ACCF-NAM Case Specifications) results in a significant redistribution of generating capacity from coal to natural gas. Nuclear and renewables generation sources grow to their constrained capacity levels. This redistribution is accompanied by a marked reduction in net utility generating capacity over the projection period relative to the ACCF-NAM Baseline projection; this results from a projection of significant demand-side energy efficiency improvements and reduced growth of electricity demand.*

Figure 11 through Figure 13 show the breakdown of net electric utility power generation by fuel type for the Baseline, Low Cost, and High Cost cases, respectively. In the Low and High Cost cases, the rate of decline in coal retirements varies in its rapidity through around 2022, but then converges post 2022 (slowest decline in the Low Cost case and highest decline in the High Cost case prior to 2022). Total generation supplied to the grid declines between the Base Case and the two cases, due to a combination of less-expensive demand-side energy efficiency improvements and increased on-site power generation. Such declines represent real revenue loss for the utilities. In 2030, total electricity generation is projected to markedly decline from 4,712 billion kW-hrs in the Base Case to 3,997 billion kW-hrs in the Low Cost case (15% decline) and to 3,816 billion kW-hrs in the High Cost case (19% decline).

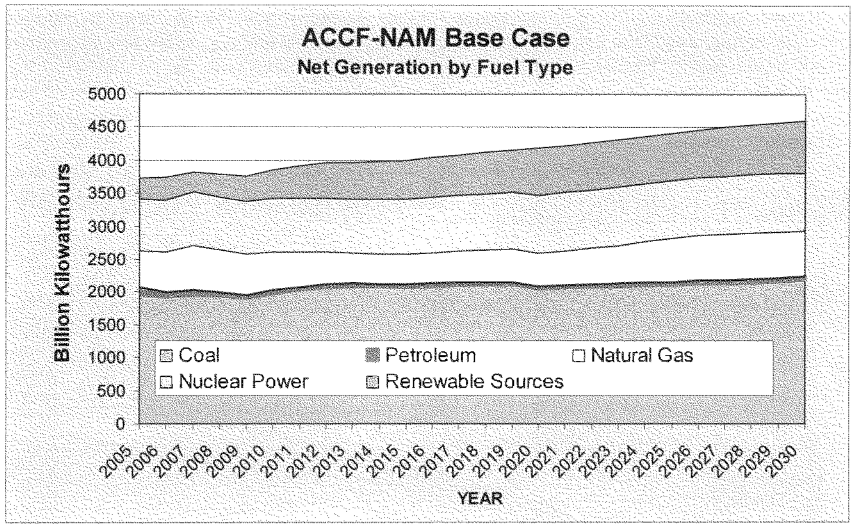

Figure 11: Baseline - - Electricity Generation by Fuel Type

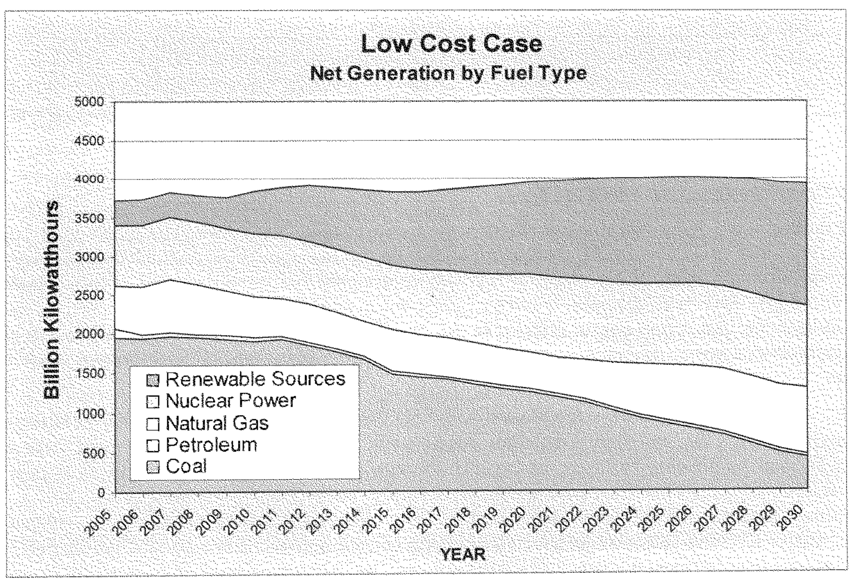

Figure 12: Low Cost Case - - Electricity Generation by Fuel

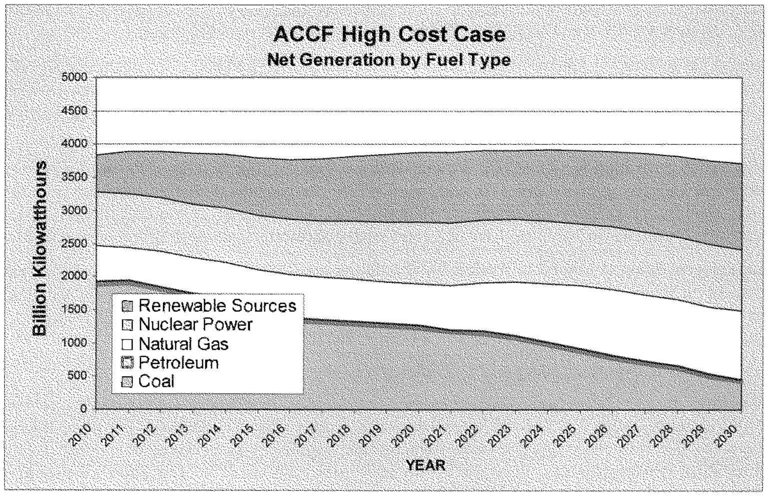

Figure 13: High Cost Case - - Electricity Generation by Fuel

Low Cost Scenario

- Coal-based generation declines from 2012 (1,837 BkWh) until 2020 (1,245 BkWh). Coal continues to play a dominant role in electric generation until about 2022 when it begins to drop significantly to satisfy emissions goals and due to gradual loss of free allowance allocations to utilities after 2025, ultimately dropping to 418 BkWh by 2030. Both IGCC/CCS (25 GW added) and NGCC/CCS (29 GW added) technologies peaked below their target limits of 30 GW each, partially due to initial year of commercialization assumed as 2020.
- Natural gas generation grows very gradually from 2012 (496 BkWh) until 2024 (636 BkWh). After 2024, natural gas generation increases more rapidly due to the rapid retirement of coal-based generation and becomes a major fuel for generation, ultimately reaching 837 BkWh by 2030.
- Renewable generation shows strong growth over the forecast, but is limited by the 10 GW per year additional capacity growth limits on wind and 5 GW per year on dedicated biomass generation as established by the scenario assumptions. Renewable generation grows from 721 BkWh in 2012 to a peak of 1,584 BkWh in 2030. Both biomass and wind generating capacity addition were maximized.
- Nuclear generation is limited to moderate growth due to assumptions regarding the market penetration that can be achieved by new net capacity growth (25 GW maximum); accounting for existing plant uprates and retirements, the model maximized new nuclear capacity generation capacity by 2030. Nuclear power generation grows from 815 BkWh in 2012 to 1,046 BkWh in 2030.

High Cost Scenario

- Coal generation gradually declines from 2012 (1,786 BkWh) until 2020 (1,225 BkWh) and remains roughly level until 2022. Coal continues to play a dominant role in electric generation until about

2022 when it begins to drop markedly to meet emissions goals, ultimately dropping to 415 BkWh by 2030. Both IGCC/CCS and NGCC/CCS reach their target limits if 15 GW each.

- Natural gas generation gradually climbs from 2012 (553 BkWh) and begins to ratchet up significantly after 2020 (625 BkWh), and very significantly after 2022 as coal-based generating capacity is retired. After 2025, natural gas becomes a predominant fuel for generation ultimately reaching 1,033 BkWh by 2030.
- Renewable generation shows strong growth over the forecast, but is limited by the 5 GW per year additional capacity growth limits on wind and 3 GW per year on dedicated biomass generation as established by the scenario assumptions. Renewable generation grows from 703 BkWh in 2012 to a peak of 1,296 BkWh in 2030. Both biomass and wind generating capacity addition were maximized.
- Nuclear generation is limited to modest growth due to assumptions regarding the market penetration that can be achieved by new net capacity growth (10 GW maximum); accounting for existing plant uprates and retirements, the model maximized new nuclear capacity generation capacity by 2030. Nuclear power generation grows from 815 BkWh in 2012 to 928 BkWh in 2030.

Impact on Gross Domestic Product and U.S. Manufacturing

Key Finding: *Due to the higher projected energy expenditures in different sectors of the economy, the ACCF-NAM model projects a loss of household income, lower commercial and industrial output, and lower employment over the projection period that results in reduced gross domestic product (GDP). The Low Cost case results project a loss of 0.2% in 2020 and 1.8% in 2030. The High Cost case results project a loss of 0.4% in 2020 and 2.4% in 2030.*

As presented previously, both the High and Low Cost cases result in projections of very high CO_2 allowance price levels that commensurately raise fuel prices. These higher fuel prices "force" the economy to undergo a significant shift in fuel conversion technology selection/utilization and fossil fuel consumption to satisfy the H.R. 2454 emissions cap goals through 2030. Due to the higher energy expenditures in different sectors of the economy, the ACCF-NAM model projects a loss of household income, lower commercial and industrial output, and lower employment over the projection period that results in reduced gross domestic product (GDP). GDP is projected to drop between $40 billion (Low Cost case) and $68 billion (High Cost case) per year in 2020 and $419 billion and $571 billion in 2030. This accounts for allocation of allowances to: electricity consumers, natural gas consumers, home heating oil and propane users, low-and moderate-income households. The free distribution of allowances through much of the model projection period (to 2025) and auctioning of allowances in the last five years effectively generates revenue from both the emitting and non-emitting sources, which, in turn, is modeled as being spent by various government entities on programs designed to help businesses and consumers reduce their emissions or reduce the impacts associated with higher energy prices (see Appendix 2). The goal was revenue neutrality.

To put these numbers in perspective, the U.S. spent $581 billion on social security payments and $371 billion on Medicare for retirees in 2007. Slower growth in the productivity of the labor force and lower levels of investment overall are responsible for lower levels of GDP. Labor productivity as measured by dollar of output per person falls 0.9% by 2030.

Table 4 shows the impact on manufacturing. By 2030, some of the largest hit sectors are transportation equipment manufacturing ($83 to $114 billion), chemical manufacturing ($48 to $61 billion), petroleum and coal products ($26 to $627 billion), and metals ($37 to $48 billion). However, this analysis did not account for Title IV of H.R. 2454, which includes provisions intended to mitigate adverse economic impacts by providing rebates for some industrial facilities that will face significant additional costs as a result of Title III. Therefore, the results shown here represent a conservative scenario during the projection period.

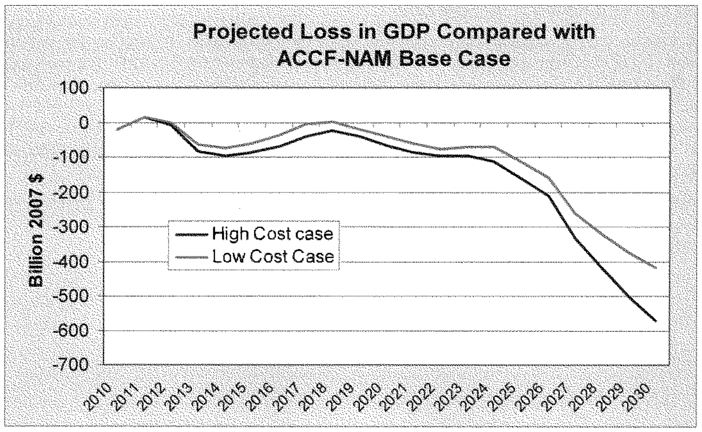

Figure 14: Loss in U.S. Gross Domestic Product

Manufacturing Sector	Base Case 2020	Base Case 2030	Low Cost Case 2020	Low Cost Case 2030	High Cost Case 2020	High Cost Case 2030
Billions $2007						
Food Products	$751.18	$894.43	-$6.60	-$22.54	-$8.93	-$30.81
Beverages and Tobacco Products	$127.43	$120.05	-$0.96	-$3.85	-$1.36	-$4.85
Textile Mills and Products	$60.17	$60.70	-$0.78	-$2.55	-$1.08	-$3.47
Apparel	$14.51	$11.80	-$0.16	-$1.32	-$0.25	-$1.82
Wood Products	$123.25	$127.38	-$2.19	-$10.18	-$3.01	-$13.88
Furniture and Related Products	$84.53	$91.43	$0.31	$2.63	$0.67	$4.00
Paper Products	$184.76	$202.62	-$3.43	-$10.42	-$4.73	-$13.07
Printing	$99.68	$108.10	-$0.03	-$0.16	-$0.08	-$0.13
Chemical Manufacturing	$797.13	$837.64	-$16.67	-$48.44	-$23.26	-$60.88
Petroleum and Coal Products	$287.18	$294.06	-$14.03	-$26.30	-$14.19	-$27.07
Plastics and Rubber Products	$278.04	$240.96	-$47.06	$17.97	-$48.97	$12.45
Leather and Leather Products	$4.06	$3.07	$0.00	$0.00	$0.00	$0.00
Stone, Clay, and Glass Products	$134.32	$125.35	-$6.03	-$17.64	-$8.69	-$22.87
Primary Metals Industry	$188.10	$163.78	-$11.68	-$36.90	-$16.79	-$47.78
Fabricated Metal Products	$311.63	$263.49	-$2.27	-$16.21	-$2.91	-$20.48
Machinery	$362.54	$256.68	-$7.29	-$31.95	-$9.64	-$39.83
Computers and Electronics	$909.67	$1,235.19	-$15.54	-$71.49	-$19.89	-$85.38
Transportation Equipment	$885.44	$1,026.05	-$27.67	-$83.26	-$34.89	-$113.88
Electrical Equipment	$166.20	$186.56	-$2.80	-$17.31	-$3.62	-$22.05
Miscellaneous Manufacturing	$280.18	$449.75	-$3.11	-$4.66	-$3.35	-$4.43
Total Industrial Value of Shipments	**$7,961.75**	**$8,838.61**	**-$144.46**	**-$470.88**	**-$171.54**	**-$575.16**

Table 4: Impact on the Value of US Manufacturing (Billion 2007 $)

NEMS/ACCF-NAM Results at the State Level

For each state, a two-page report was prepared to show the impact of H.R. 2454 on the state under the "High" and "Low" cost scenarios using the assumptions provided by ACCF-NAM. The two-page reports describe the potential higher energy costs and resultant impacts in each state on jobs, household income, economic growth, industrial production, low income and elderly citizens, and state budgets. To prepare the state-specific analyses, the regional NEMS/ACCF-NAM 2 results were post-processed based on historical trends/relationships to get results for economic growth, household income, jobs, industrial production and prices at the state.[20]

Tables summarizing the impacts for each of the 50 states are provided below in Table 5 through Table 10.

[20] NEMS reports all of these results by census regions.

Table 5: Loss in Employment (Thousands of Jobs)

State	LOW CASE PROJECTION 2020	LOW CASE PROJECTION 2030	HIGH CASE PROJECTION 2020	HIGH CASE PROJECTION 2030
Alabama	0.18	-27.94	-1.25	-38.05
Alaska	0.02	-4.28	-0.17	-5.82
Arizona	0.18	-29.61	-1.26	-40.32
Arkansas	0.10	-17.10	-0.70	-23.28
California	1.26	-221.27	-8.76	-301.36
Colorado	0.16	-26.32	-1.12	-35.85
Connecticut	0.12	-17.28	-0.82	-23.53
Delaware	0.03	-4.49	-0.19	-6.12
DC	0.02	-3.23	-0.14	-4.40
Florida	0.55	-90.63	-3.79	-123.43
Georgia	0.29	-47.72	-2.00	-64.99
Hawaii	0.05	-8.14	-0.32	-11.09
Idaho	0.05	-7.38	-0.31	-10.05
Illinois	0.57	-88.36	-3.97	-120.34
Indiana	0.28	-43.51	-1.95	-59.26
Iowa	0.15	-24.02	-1.01	-32.72
Kansas	0.13	-21.42	-0.90	-29.17
Kentucky	0.17	-25.71	-1.15	-35.01
Louisiana	0.15	-26.07	-1.07	-35.50
Maine	0.05	-6.59	-0.31	-8.98
Maryland	0.18	-30.44	-1.27	-41.45
Massachusetts	0.22	-32.08	-1.53	-43.70
Michigan	0.43	-66.66	-2.99	-90.79
Minnesota	0.25	-42.09	-1.77	-57.32
Mississippi	0.11	-16.59	-0.74	-22.60
Missouri	0.26	-43.26	-1.82	-58.91
Montana	0.03	-4.96	-0.21	-6.76
Nebraska	0.09	-14.42	-0.61	-19.63
Nevada	0.08	-12.72	-0.54	-17.32
New Hampshire	0.05	-6.97	-0.33	-9.50
New Jersey	0.29	-50.70	-2.03	-69.05
New Mexico	0.06	-9.33	-0.40	-12.71
New York	0.62	-108.26	-4.32	-147.44
North Carolina	0.27	-44.87	-1.88	-61.11
North Dakota	0.03	-5.31	-0.22	-7.23
Ohio	0.51	-79.76	-3.58	-108.63
Oklahoma	0.13	-22.10	-0.91	-30.10
Oregon	0.13	-23.45	-0.93	-31.94
Pennsylvania	0.41	-71.58	-2.86	-97.49
Rhode Island	0.04	-5.29	-0.25	-7.21
South Carolina	0.13	-21.02	-0.88	-28.63
South Dakota	0.04	-6.42	-0.27	-8.74
Tennessee	0.25	-38.20	-1.71	-52.03
Texas	0.85	-144.60	-5.93	-196.93
Utah	0.08	-13.31	-0.56	-18.12
Vermont	0.02	-3.36	-0.16	-4.57
Virginia	0.25	-41.40	-1.73	-56.39
Washington	0.24	-41.46	-1.64	-56.46
West Virginia	0.05	-8.21	-0.34	-11.18
Wisconsin	0.27	-41.66	-1.87	-56.74
Wyoming	0.02	-2.87	-0.12	-3.91

Table 6: Disposable Household Income Impact (2007$)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	-77	-588	-181	-1010
Alaska	-122	-704	-259	-1227
Arizona	-79	-461	-187	-850
Arkansas	-61	-433	-153	-781
California	-139	-799	-295	-1393
Colorado	-92	-537	-218	-991
Connecticut	-198	-1212	-385	-1990
Delaware	-95	-560	-216	-1009
DC	-129	-765	-296	-1380
Florida	-87	-515	-199	-929
Georgia	-87	-516	-199	-930
Hawaii	-122	-706	-260	-1231
Idaho	-76	-441	-179	-813
Illinois	-167	-1096	-328	-1782
Indiana	-131	-863	-258	-1402
Iowa	-125	-823	-252	-1351
Kansas	-130	-851	-261	-1397
Kentucky	-75	-571	-176	-980
Louisiana	-68	-485	-171	-874
Maine	-105	-645	-205	-1059
Maryland	-115	-683	-264	-1232
Massachusetts	-178	-1090	-346	-1789
Michigan	-134	-883	-264	-1435
Minnesota	-145	-948	-291	-1557
Mississippi	-74	-561	-173	-963
Missouri	-121	-793	-243	-1301
Montana	-71	-414	-168	-764
Nebraska	-131	-858	-263	-1410
Nevada	-95	-551	-224	-1017
New Hampshire	-151	-922	-293	-1514
New Jersey	-201	-1259	-387	-2049
New Mexico	-70	-409	-166	-755
New York	-179	-1123	-345	-1827
North Carolina	-79	-467	-180	-842
North Dakota	-116	-762	-234	-1252
Ohio	-133	-873	-261	-1419
Oklahoma	-69	-490	-173	-883
Oregon	-100	-577	-212	-1005
Pennsylvania	-148	-926	-285	-1507
Rhode Island	-149	-914	-290	-1501
South Carolina	-74	-436	-168	-786
South Dakota	-128	-841	-258	-1380
Tennessee	-85	-648	-199	-1114
Texas	-86	-612	-216	-1103
Utah	-87	-503	-205	-929
Vermont	-120	-732	-232	-1202
Virginia	-103	-608	-235	-1096
Washington	-121	-696	-256	-1213
West Virginia	-65	-385	-149	-694
Wisconsin	-134	-881	-264	-1432
Wyoming	-94	-546	-222	-1007

Table 7: Loss in Gross State Product (Million 2007$)

	LOW CASE PROJECTION		HIGH CASE PROJECTION	
State	2020	2030	2020	2030
Alabama	-444	-4676	-762	-6379
Alaska	-100	-1051	-171	-1434
Arizona	-662	-6976	-1138	-9517
Arkansas	-256	-2701	-440	-3685
California	-4954	-52208	-8513	-71226
Colorado	-638	-6722	-1096	-9171
Connecticut	-581	-6124	-999	-8355
Delaware	-236	-2487	-406	-3393
DC	-163	-1715	-280	-2340
Florida	-1955	-20607	-3360	-28113
Georgia	-1085	-11432	-1864	-15597
Hawaii	-158	-1665	-271	-2271
Idaho	-141	-1483	-242	-2024
Illinois	-1676	-17665	-2881	-24100
Indiana	-704	-7414	-1209	-10115
Iowa	-347	-3657	-596	-4990
Kansas	-310	-3262	-532	-4450
Kentucky	-418	-4402	-718	-6005
Louisiana	-483	-5089	-830	-6943
Maine	-992	-10457	-1705	-14267
Maryland	-719	-7573	-1235	-10331
Massachusetts	-132	-1392	-227	-1899
Michigan	-1144	-12058	-1966	-16450
Minnesota	-703	-7407	-1208	-10105
Mississippi	-234	-2467	-402	-3365
Missouri	-638	-6722	-1096	-9171
Montana	-85	-900	-147	-1228
Nebraska	-71	-750	-122	-1023
Nevada	-196	-2066	-337	-2819
New Hampshire	-163	-1722	-281	-2349
New Jersey	-1291	-13600	-2218	-18554
New Mexico	-322	-3397	-554	-4635
New York	-2958	-31171	-5083	-42526
North Carolina	-1057	-11142	-1817	-15201
North Dakota	-213	-2242	-366	-3059
Ohio	-1315	-13860	-2260	-18909
Oklahoma	-340	-3580	-584	-4884
Oregon	-446	-4697	-766	-6407
Pennsylvania	-1439	-15162	-2472	-20685
Rhode Island	-129	-1355	-221	-1848
South Carolina	-417	-4399	-717	-6001
South Dakota	-92	-969	-158	-1322
Tennessee	-680	-7164	-1168	-9774
Texas	-2836	-29887	-4874	-40775
Utah	-265	-2791	-455	-3807
Vermont	-70	-736	-120	-1004
Virginia	-1033	-10883	-1775	-14847
Washington	-821	-8653	-1411	-11805
West Virginia	-150	-1586	-259	-2163
Wisconsin	-647	-6815	-1111	-9297
Wyoming	-67	-710	-116	-968

Table 8: Change in Retail Gasoline Prices (2007$ per MMBtu)

State	LOW CASE PROJECTION 2020	LOW CASE PROJECTION 2030	HIGH CASE PROJECTION 2020	HIGH CASE PROJECTION 2030
Alabama	$2.46	$6.30	$0.81	$1.95
Alaska	$2.46	$6.84	-$0.05	$2.05
Arizona	$2.55	$6.57	$0.84	$1.99
Arkansas	$2.53	$6.18	$0.82	$1.88
California	$2.39	$6.65	$0.80	$1.99
Colorado	$2.50	$6.44	$0.82	$1.95
Connecticut	$2.57	$6.45	$0.80	$1.98
Delaware	$2.59	$6.63	$0.85	$2.06
DC	$2.83	$7.26	$0.93	$2.25
Florida	$2.45	$6.27	$0.80	$1.95
Georgia	$2.32	$5.95	$0.76	$1.85
Hawaii	$2.70	$7.51	$0.90	$2.25
Idaho	$2.52	$6.49	$0.83	$1.97
Illinois	$2.53	$6.37	$0.85	$2.00
Indiana	$2.42	$6.10	$0.81	$1.91
Iowa	$2.47	$5.99	$0.83	$1.58
Kansas	$2.54	$6.15	$0.85	$1.62
Kentucky	$2.56	$6.54	$0.84	$2.03
Louisiana	$2.54	$6.18	$0.82	$1.88
Maine	$2.55	$6.41	$0.79	$1.97
Maryland	$2.69	$6.90	$0.88	$2.14
Massachusetts	$2.53	$6.36	$0.78	$1.95
Michigan	$2.45	$6.18	$0.82	$1.94
Minnesota	$2.56	$6.19	$0.86	$1.63
Mississippi	$2.46	$6.29	$0.81	$1.95
Missouri	$2.45	$5.94	$0.82	$1.56
Montana 2	$2.55	$6.57	$0.84	$1.99
Nebraska	$2.50	$6.05	$0.84	$1.59
Nevada	$2.63	$6.79	$0.87	$2.06
New Hampshire	$2.49	$6.26	$0.77	$1.92
New Jersey	$2.47	$6.15	$0.78	$1.99
New Mexico	$2.49	$6.41	$0.82	$1.94
New York	$2.54	$6.31	$0.80	$2.04
North Carolina	$2.51	$6.43	$0.82	$2.00
North Dakota	$2.52	$6.11	$0.84	$1.61
Ohio	$2.52	$6.36	$0.84	$1.99
Oklahoma	$2.43	$5.93	$0.79	$1.81
Oregon	$2.39	$6.64	$0.79	$1.99
Pennsylvania	$2.54	$6.31	$0.80	$2.04
Rhode Island	$2.61	$6.55	$0.81	$2.01
South Carolina	$2.43	$6.23	$0.80	$1.93
South Dakota	$2.49	$6.04	$0.84	$1.59
Tennessee	$2.50	$6.39	$0.82	$1.98
Texas	$2.52	$6.13	$0.81	$1.87
Utah	$2.49	$6.43	$0.82	$1.95
Vermont	$2.50	$6.29	$0.78	$1.93
Virginia	$2.54	$6.50	$0.83	$2.02
Washington	$2.39	$6.64	$0.79	$1.99
West Virginia	$2.65	$6.79	$0.87	$2.11
Wisconsin	$2.60	$6.54	$0.87	$2.05
Wyoming	$2.39	$6.17	$0.79	$1.87

Table 9: Change in Residential Electricity Prices (2007 $ per MMBtu)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	$0.05	$13.86	$0.76	$5.95
Alaska	$3.22	$6.44	-$0.05	$1.30
Arizona	$4.90	$9.99	-$0.52	$12.02
Arkansas	$0.49	$9.44	$2.33	$6.90
California	$3.18	$6.37	-$0.15	$1.28
Colorado	$4.75	$9.67	-$0.50	$11.64
Connecticut	$2.68	$9.57	$1.71	$4.11
Delaware	$2.39	$13.26	$0.09	$6.21
DC	$2.18	$12.11	$0.09	$5.67
Florida	$2.38	$13.22	$0.09	$6.19
Georgia	$2.08	$11.54	$0.08	$5.41
Hawaii	$4.72	$9.44	-$0.23	$1.90
Idaho	$3.54	$7.22	-$0.37	$8.68
Illinois	$0.25	$11.36	$1.28	$6.75
Indiana	$0.22	$10.03	$1.13	$5.96
Iowa	$2.58	$8.71	$0.50	$10.57
Kansas	$2.26	$7.63	$0.44	$9.27
Kentucky	$0.04	$11.09	$0.61	$4.76
Louisiana	$0.51	$9.96	$2.46	$7.28
Maine	$2.67	$9.56	$1.71	$4.10
Maryland	$2.11	$11.71	$0.08	$5.49
Massachusetts	$2.68	$9.57	$1.71	$4.11
Michigan	$0.26	$11.69	$1.32	$6.95
Minnesota	$2.30	$7.79	$0.45	$9.45
Mississippi	$0.06	$14.76	$0.81	$6.33
Missouri	$2.04	$6.90	$0.39	$8.38
Montana 2	$4.40	$8.98	-$0.46	$10.80
Nebraska	$2.02	$6.83	$0.39	$8.29
Nevada	$5.59	$11.40	-$0.59	$13.71
New Hampshire	$2.69	$9.61	$1.72	$4.13
New Jersey	$1.12	$12.32	$2.59	$5.51
New Mexico	$4.97	$10.13	-$0.52	$12.19
New York	$1.48	$16.24	$3.42	$7.27
North Carolina	$2.18	$12.08	$0.09	$5.66
North Dakota	$1.94	$6.57	$0.38	$7.98
Ohio	$0.26	$11.60	$1.31	$6.89
Oklahoma	$0.48	$9.36	$2.31	$6.84
Oregon	$1.80	$3.59	-$0.09	$0.72
Pennsylvania	$0.97	$10.62	$2.24	$4.75
Rhode Island	$2.59	$9.26	$1.66	$3.97
South Carolina	$2.12	$11.76	$0.08	$5.51
South Dakota	$2.19	$7.41	$0.42	$9.00
Tennessee	$0.05	$12.32	$0.68	$5.29
Texas	$0.64	$12.36	$3.06	$9.04
Utah	$4.07	$8.29	-$0.43	$9.98
Vermont	$2.70	$9.64	$1.72	$4.14
Virginia	$2.05	$11.36	$0.08	$5.32
Washington	$1.61	$3.22	-$0.08	$0.65
West Virginia	$1.59	$8.83	$0.06	$4.14
Wisconsin	$0.28	$12.50	$1.41	$7.43
Wyoming	$4.11	$8.39	-$0.43	$10.09

Table 10: Change in Residential Natural Gas Prices (2007$/MMBtu)

State	LOW CASE PROJECTION 2020	LOW CASE PROJECTION 2030	HIGH CASE PROJECTION 2020	HIGH CASE PROJECTION 2030
Alabama	-$0.47	$9.30	$0.06	$12.20
Alaska	-$0.27	$4.15	-$0.05	$5.35
Arizona	-$0.77	$10.85	-$0.16	$13.92
Arkansas	-$0.43	$8.77	$0.08	$11.53
California	-$0.50	$7.73	-$0.09	$9.95
Colorado	-$0.48	$6.84	-$0.10	$8.77
Connecticut	-$0.34	$8.26	$0.10	$10.87
Delaware	-$0.33	$7.70	$0.09	$10.17
DC	-$0.37	$8.69	$0.10	$11.48
Florida	-$0.46	$10.65	$0.12	$14.06
Georgia	-$0.36	$8.44	$0.10	$11.15
Hawaii	-$1.40	$21.88	-$0.27	$28.17
Idaho	-$0.55	$7.81	-$0.12	$10.02
Illinois	-$0.39	$7.48	$0.03	$9.73
Indiana	-$0.43	$8.28	$0.03	$10.78
Iowa	-$0.43	$7.85	$0.02	$10.20
Kansas	-$0.43	$7.87	$0.02	$10.22
Kentucky	-$0.37	$7.28	$0.05	$9.54
Louisiana	-$0.41	$8.37	$0.08	$11.01
Maine	-$0.30	$7.29	$0.09	$9.59
Maryland	-$0.33	$7.69	$0.09	$10.16
Massachusetts	-$0.33	$7.95	$0.09	$10.47
Michigan	-$0.37	$7.08	$0.03	$9.21
Minnesota	-$0.40	$7.29	$0.01	$9.48
Mississippi	-$0.38	$7.43	$0.05	$9.74
Missouri	-$0.46	$8.44	$0.02	$10.96
Montana	-$0.51	$7.16	-$0.11	$9.19
Nebraska	-$0.38	$6.91	$0.01	$8.99
Nevada	-$0.64	$9.01	-$0.13	$11.55
New Hampshire	-$0.32	$7.72	$0.09	$10.17
New Jersey	-$0.29	$6.88	$0.07	$9.04
New Mexico	-$0.55	$7.79	-$0.12	$9.99
New York	-$0.37	$8.55	$0.08	$11.24
North Carolina	-$0.34	$7.88	$0.09	$10.40
North Dakota	-$0.36	$6.67	$0.01	$8.67
Ohio	-$0.44	$8.44	$0.03	$10.98
Oklahoma	-$0.38	$7.67	$0.07	$10.08
Oregon	-$0.57	$8.97	-$0.11	$11.55
Pennsylvania	-$0.35	$8.12	$0.08	$10.67
Rhode Island	-$0.32	$7.75	$0.09	$10.20
South Carolina	-$0.34	$7.96	$0.09	$10.51
South Dakota	-$0.40	$7.30	$0.01	$9.49
Tennessee	-$0.38	$7.45	$0.05	$9.77
Texas	-$0.37	$7.58	$0.07	$9.96
Utah	-$0.48	$6.73	-$0.10	$8.63
Vermont	-$0.28	$6.76	$0.08	$8.90
Virginia	-$0.34	$7.94	$0.09	$10.48
Washington	-$0.52	$8.14	-$0.10	$10.48
West Virginia	-$0.28	$6.54	$0.08	$8.63
Wisconsin	-$0.42	$8.08	$0.03	$10.52
Wyoming	-$0.49	$6.97	-$0.10	$8.94

APPENDIX 1: ADDITIONAL INFORMATION ON THE OPERATION OF THE NEMS MODEL

1) How is supply-side energy conversion efficiency accounted for in NEMS?

Each supply-side technology used by NEMS (e.g., nuclear, natural gas combined cycle) incorporates a design specification that accounts for temporal changes in technology efficiency based on commercial implementation experience and technology improvement expectation. Efficiency values are specified for the year that a technology is assumed to become commercially available for deployment and for some year in the future (different for each technology) that accounts for improvements associated with experiential learning and continued technology R&D. The model interpolates to establish annual efficiency improvements for each supply-side technology.

2) What is the sensitivity of the model to supply-side technology capital costs for power generation?

For capacity expansion decision-making in any given year of the projection, NEMS calculates an associated present-value cost of each competing technology based on **capital cost, fixed & variable operating and maintenance costs** (O&M), and projected **fuel consumption costs**. In concert with specified operating and environmental constraints, the model chooses the least-cost mix of technologies to meet projected energy demand for the projection period. Therefore, relative differences in technology capital costs directly impact the cost-competitiveness of each technology and the extent to which annual capacity is added for each. Commercialization-year capital costs are user-specified for each technology type and the model projects learning-based cost reductions based on the total capacity added for each technology over the projection period. Therefore, the relative technology capital costs often change over the projection period depending on the relative levels of technology deployment.

With regard to operating dispatch decisions, NEMS only chooses the mix of plants that minimizes fuel, variable O&M, and environmental costs, subject to meeting electricity demand and environmental constraints.

APPENDIX 2: H.R. 2454 MODELING ASSUMPTIONS

Model Function

NEMS/ACCF-NAM 2 endogenously calculates changes in energy-related CO_2 emissions for the cases assessed in this study. The cost of using each fossil fuel includes the costs associated with the CO_2 allowances needed to cover the emissions produced when they are used. These fuel cost "adjustments" influence energy demand and associated energy-related CO_2 emissions. The allowance price also determines the reductions in projected baseline emissions of other greenhouse gases based on assumed abatement cost relationships. Since emission allowance banking is allowed by H.R. 2454, the model solves for the profile of allowance prices such that cumulative emissions match the cumulative emissions cap without requiring allowance borrowing and with an annual price escalation limit that is consistent with a cost of capital specification by ACCF-NAM.

The NEMS/ACCF-NAM 2 Macroeconomic Activity Module (MAM), based on the Global Insight U.S. Model, interacts with the energy supply, demand, and conversion modules of NEMS/ACCF-NAM 2 to solve for the energy-economy equilibrium. MAM reacts to changes in energy prices, energy consumption, and allowance revenues, interactively solving for the effect on macroeconomic and industry level variables, such as real gross domestic product (GDP), interest rates, the unemployment rate, value of real industrial shipments, housing starts, commercial floorspace, and many other macroeconomic metrics.

SAIC modeled the following key provisions of H.R. 2454.

The AEO2009 Reference Case

In 2008/2009 the EIA released 3 different versions of the AEO2009. In Dec. 2008, the EIA released the preliminary version of the AEO2009. In March 2009, the EIA released a version that included the provisions of the Energy Improvement and Extension Act (EIEA) of 2008 that was passed into law in October 2008. In April 2009, another version of the AEO2009 was released that included the provisions of the American Recovery and Reinvestment Act (ARRA) of 2009 passed into law in February 2009. *The April release of the AEO2009 also included a new macroeconomic outlook that took into account the impact of the significant worsening of the ongoing recession that was not included in the March release.*

In the near term, the ARRA of 2009 is projected to decrease the magnitude and duration of the current recession. Further out in the projection period, however, ARRA of 2009 adversely affects macroeconomic performance as the larger budget deficits that result from the additional spending embedded in the stimulus package cause interest rates to be higher and GDP growth to be lower.

SAIC's baseline forecast for WMB is based on the AEO2009 projection that includes the impact of the current recession and the provisions of ARRA 2009, to the extent that EIA was able to model them in NEMS.[21] NEMS model changes by EIA reflect the following programs of ARRA 2009:

- Weatherization, assisted housing, energy efficiency, and conservation block grants
- State energy programs
- Plug in hybrid and electric vehicle tax credits
- Tax credits for renewables
- Loan guarantees for renewables, biofuels and transmission projects
- Support for CCS
- Smart grid expenditures

[21] The details of the implementation are described in, "*An Updated Annual Energy Outlook 2009 Reference Case Revisions Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in Economic Outlook.*" April 2009, Energy Information Administration.

Title I – Clean Energy

Subtitle A – Combined Efficiency and Renewable Electricity Standard

Section 101 requires electric utilities that sell more than 4 million MWh of electricity to consumers meet the following percentage of electricity load generated from a combination of renewable sources and energy efficiency savings:

Calendar Year	Required Annual Percentage
2012	6
2013	6
2014	8.5
2015	8.5
2016	11
2017	11
2018	14
2019	14
2020	17.5
2021	17.5
2022	21
2023	21
2024	23
2025-2039	25

Table A2-1. Combined H.R. 2454 Renewable and Efficiency Standard

The required annual percentage can be specified at the 13 Electricity Market Module regions or at the national level in NEMS. SAIC modified the NEMS' Electricity Market Module and the Residential/Commercial/Industrial Demand Module inputs to account for a goal of 15% renewables and 5% energy efficiency by 2020. As stipulated in H.R. 2454, nuclear generation was excluded from the base in calculating the required annual percentages.

With regard to renewables, the model results (Figure A2-1) exceed the minimum renewable requirements specified by H.R. 2454 due to the supply technology constraints applied to fossil, renewable, and nuclear capacity expansion. See the discussion below under Title II for the energy efficiency changes.

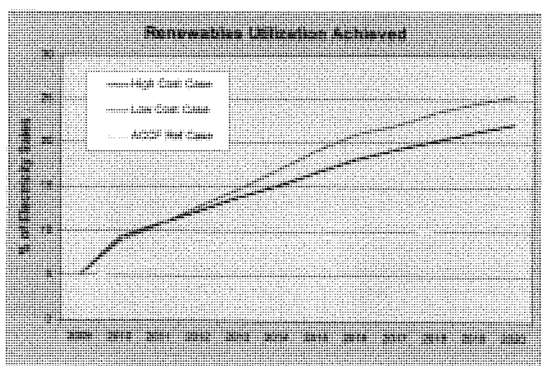

Figure A2-1. Renewables Utilization Achieved

Title II – Energy Efficiency

The various provisions of Title II provide impetus for energy efficiency improvements for buildings, lighting and appliances, transportation, and industries. While some specific provisions of this Title are specific, others are not. For example, Section 204 of Title II establishes a building energy performance labeling program. The impact of such programs is difficult to estimate and SAIC did not specifically model provisions of this type. However, in order to model the implications of energy efficiency improvements in its entirety, SAIC implemented the EIA high technology side-cases for the residential, commercial and transportation sectors. The high technology case assumes that more energy consuming technologies are available for consumers earlier, at a lower cost and higher levels of energy efficiency. The results of this approach are presented in Figures A2-2 and A2-3 below for the commercial, residential, and industrial sectors. In 2020, the average energy efficiency improvement for all sectors, based on an energy intensity metric (total energy consumed/ft^2), is approximately 5% per the bill specification.

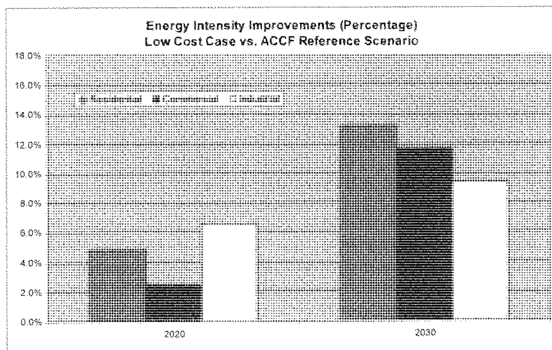

Figure A2-2. Low Cost Case Energy Efficiency Improvements Comparison

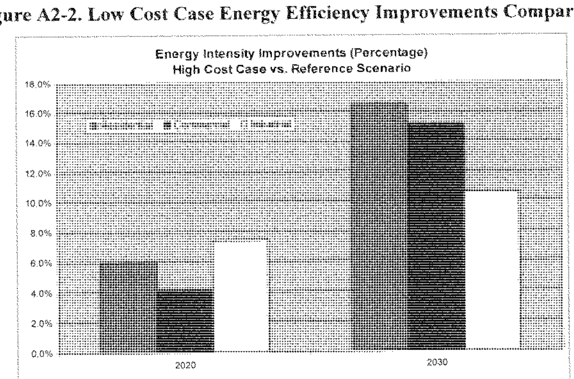

Figure A2-3. High Cost Case Energy Efficiency Improvements Comparison

Title III – Reducing Global Warming

Title III is the main cap and trade provision of H.R. 2454. GHG emission targets decline each calendar year according to the following schedule:

- 2012: 4,627 MtCO2e (97% of 2005 emissions levels, or 3% below)
- 2020: 5,056 MtCO2e (83% of 2005 emissions levels, or 17% below)
- 2030: 3,533 MtCO2e (58% of 2005 emissions levels, or 42% below)
- 2050: 1,035 MtCO2e (17% of 2005 emissions levels , or 83% below)

The following sectors are covered with a staggered initial compliance year:

Staggered Initial Compliance Years for Covered Sources Sector	 Point of Regulation	Initial Compliance Year
Electricity	Downstream (power plants)	2012
Transportation/ Industrial	Mid/Upstream for producers and importers of petroleum-based or coal-based liquid fuel, petroleum coke, or natural gas liquid	2012
Industrial	Mid/Upstream for producers and importers of specific GHGs (fossil fuel-based carbon dioxide; nitrous oxide; perfluorocarbons; sulfur hexafluoride; nitrogen trifluoride; any other fluorinated gas that is a GHG, or any combination of such GHGs)	2012
Industrial	Downstream for specific industrial sectors (e.g., cement, primary aluminum production, ammonia manufacturing, hydrochlorofluorocarbons production, lime manufacturing, nitric acid production, coal-based liquid or gaseous fuel production, petroleum refining, etc.)	2012
Industrial	Downstream for chemical or petrochemical sector	2014
Industrial	Downstream for specific sectors (e.g., ethanol production, food processing, glass production, iron and steel production, pulp and paper, etc.)	2014
Industrial	Downstream for fossil fuel-fired combustion devices not covered under any other sectors	2014
Commercial/ Residential	Midstream (natural gas local distribution companies)	2016
Other	Any geological sequestration site	2012

Table A2- 2. Compliance Year Specifications by Sector

SAIC made some value adjustments to reflect the staggered initial compliance years based on the proportion of actual covered emission sources. This was very confusing in the bill, but we decided to make an adjustment that established a consistent specification. See Figure A2-4 below.

H.R. 2454 calls for increasingly stringent emissions caps beyond 2030, the forecast horizon for NEMS/ACCF-NAM 2. Meeting these post-2030 caps will require significant emission reductions outside the electricity sector, which is the predominant source of early emissions reductions and increasing price pressure, assuming no technological breakthrough in transportation and other energy conversion processes dependent on fossil fuels. As a result, SAIC assumes that there will be an allowance bank balance at the end of 2030, albeit banking of allowances is unlimited in H.R. 2454. ACCF-NAM specified a target allowance bank of 5 billion metric tons by 2030 in order to comply with more stringent caps beyond 2030 and account for the long utility phase-in period to 2025. A two year compliance period allows borrowing from the bank one year ahead without penalty. Borrowing allowances from years two through five can be done, but with an interest rate penalty. *It was assumed that the interest rate penalty would likely prevent any type of borrowing, and therefore borrowing was not modeled.*

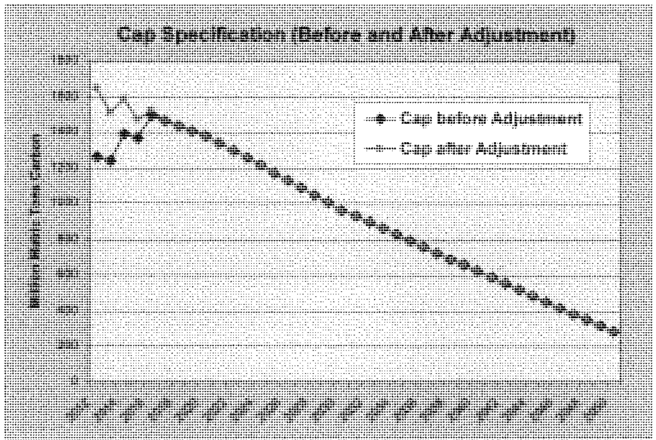

Figure A2-4. Carbon Cap Specification Adjustment

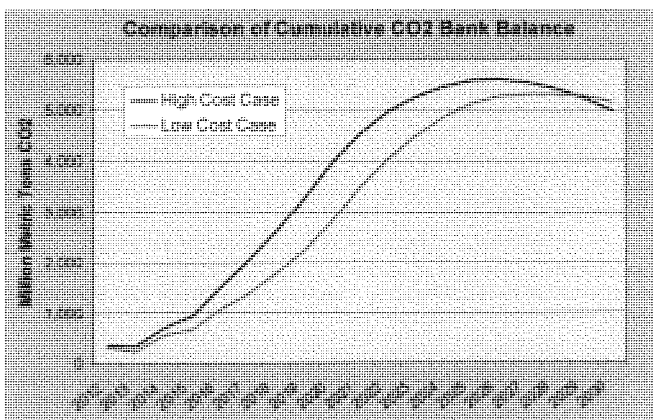

Figure A2-5. Comparison of Bank Balance Outcome

Strategic Reserves were not specifically modeled. However, the implications of a strategic reserve were modeled by preventing allowance prices from increasing by more than **10%** each year. This compares with EIA's specification of 7.4% per year.

Offsets are limited to 2,000 million metric tons per year evenly split between domestic and international offsets. However, depending on whether limits on domestic offsets are met, there is a pro rata sharing which may alter these limits. The percentage of total offsets allowed in the caps is approximately 30%. It was assumed that 15% of domestic offsets and 15% international offsets were potentially available. The offset availability and costs used in this study were those incorporated into the April version of EIA's NEMS model, which were the same as used for their S. 2191 study.[22]

H.R. 2454 Allowance Allocation Implementation

The free distribution and auctioning of allowances to both emitting and non-emitting CO_2 sources generates direct revenue and tax revenue for the government, which, in turn, is assumed to be spent on programs designed to help businesses and consumers reduce their release of greenhouse emissions or lessen the direct impacts associated with higher energy prices. In order to model the allowance allocations, SAIC applied a similar approach to implement H.R. 2454 that EIA originally designed for implementing S.2191, with modifications as specified by the W-M bill. Free allowance allocations, such as for the electricity sector, are placed into a "Grandfathered" category that is implemented via code, and revenues from "Remaining" allowances are implemented together with allowance auctions by mapping into one of the following government expenditure "Accounts":

- Local Government expenditure
- Federal Government expenditure
- International transfer payment
- Domestic transfer payment

Basically, the W-M bill allocates free allowances to 15 "players" for Consumer Protection, Transition Assistance for Industry, Energy Efficiency and Clean Energy Technology, and other public purposes. Section 782 of Title III describes the allowance allocation scheme. Allocations can be classified into four major categories by purpose:

- Consumer Protection (53% of total cumulative emission allowances from 2012-2030)
- Transition Assistance for Industry (13% from 2012-2030)
- Energy Efficiency and Clean Energy Technology (12% from 2012-2030)
- Other Public Purposes (13% from 2012-2030)

Of the various groups identified for consumer protection and transitional assistance, SAIC directly modeled the allocation of allowances to:

- Electricity consumers (accounting for 31% of total cumulative allowances from 2012-2030)
- Natural gas consumers (accounting for 5.7%)
- Home heating oil and propane users (accounting for 1%)
- Low-and Moderate-Income Households (accounting for 15%)

Since H.R. 2454 is unclear about the allocation split between generators and LDCs in the electricity sector, SAIC modeled the implications of free allowances by assuming the same ratio as assumed in the Lieberman-Warner S. 2191 analysis. Making this assumption allocates about 19% of the allowances to generators over the 2012-2030 period and 13% of the allowances to LDCs.

SAIC modeled the implications of free allowances to natural gas LDCs by making the following adjustments to residential and commercial natural gas prices. The amount of allocated allowances for each year was multiplied by the allowance price for that year to determine the total value of the allocation. This value was then divided by the annual consumption in the residential and commercial sectors to generate a per dollar Btu value. H.R. 2454 stipulates that the value of those allowances should not undermine the consumer's incentive to conserve and invest in energy efficiency measures by lowering

[22] "Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007, April 2008, SR/OIAF/2008-01, http://www.eia.doe.gov/oiaf/servicerpt/s2191/pdf/sroiaf(2008)01.pdf.

energy costs. In other words, they cannot be rebated to consumers in some proportion of the amount of natural gas that they use. The allocation value has to be returned to customers either through demand-side management programs or utility investment in energy efficiency or through fixed rebates or credits on bills. If the rebate is applied to the fixed charge portion of a customer's bill, then the total bill can be lower despite the demand charge being higher because of carbon caps. NEMS does not have the flexibility to allow user-defined adjustments of natural gas bills. In order to model the impact of lower bills indirectly, SAIC assumed that the fixed charge portion of the per dollar Btu value from free allowances as being 61% of the calculated value for the residential sector.[23] SAIC further assumed that half of that fixed charge value was rebated using allowance funds. The resulting per dollar Btu value was then subtracted from projected residential and commercial end use prices to reflect lower natural gas bills. The remainder of the free allowances was *assumed* to be invested in programs to improve end use efficiency.

The free allocation of allowances to protect heating oil customers was modeled without the restrictions imposed for natural gas customers.

For each of the "Remaining" allocation areas, such as assistance to low and moderate income households, SAIC's representation mapped them to the following categories of macroeconomic expenditures:

- Real federal non-Medicaid grants to state & local governments
- Real federal non-defense consumption excluding depreciation & personnel
- Real state & local consumption excluding capital consumption & personnel
- State and local government transfer receipts
- Other federal government transfers to rest of the world
- Federal taxes on production and imports other than for a VAT
- State and local government transfer receipts
- Non-Medicare and Social Security full-employment fed. transfer payments
- State & local non-medical transfer payments

These taxes and expenditures are then grouped into one of the above four government "Accounts" and each account's share is then quantified. Having the total carbon revenue computed, each account receives its money based on its share in the mapping.

Figure A2-5 shows the outcome of above mapping:

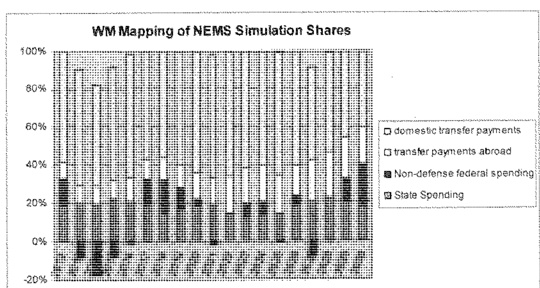

Figure A2-5. Mapping of Remaining Allocation Shares into Government Accounts

[23] Based on EIA data, the average fixed charge for the 1990-2008 period was estimated at 61% in the residential sector by examining the ratio of wellhead to residential prices. The commercial ratio averaged 54% for the period.

Allowance Auction Implementation

SAIC estimated auctions (CCCC Allocations in NEMS) by subtracting all free allocations from the allowance cap. The auctions curve begins at 14%, quickly drops to around 1%, and rises suddenly to 11% in 2026, and then 48% in 2030. In this implementation, 100% of auction revenues were directed to general government revenues in order to retain budget neutrality. Figure A2-6 summarizes the combined mapping of the revenue of 'remaining allowances' and auctioned allowances to the government accounts and industry. Figure A2-7 maps the nominal government revenue to expenditures by share. Figure A2-8 depicts the related government spending results.

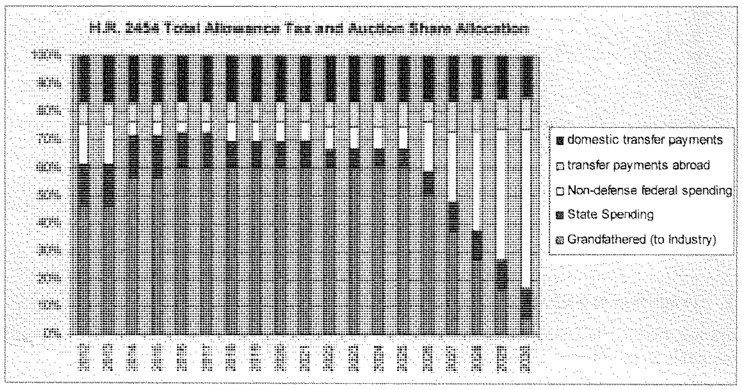

Figure A2-6. Mapping of Total Allowance Tax and Auction Revenue Shares

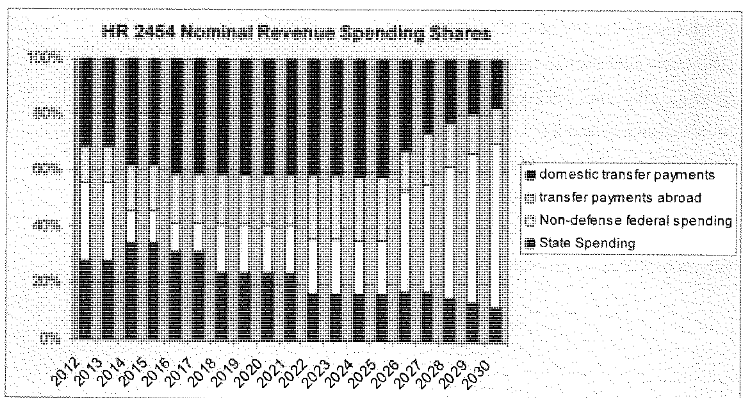

Figure A2-7. Mapping of Nominal Revenue Expenditures by Share

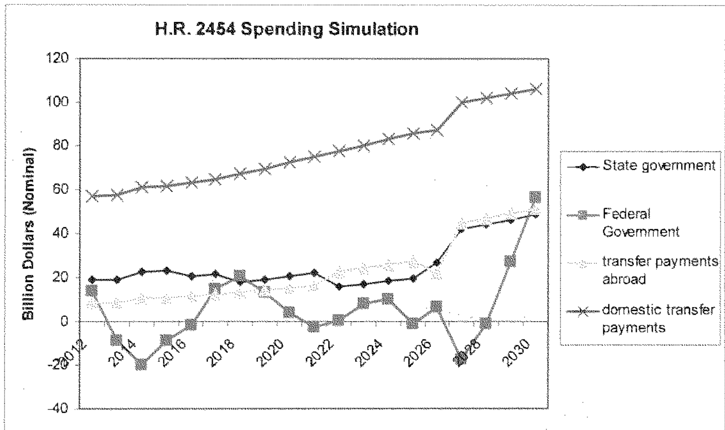

Figure A2-8. Expenditures by Category

Title IV – Transition to a Clean Energy Economy

SAIC did not model allowance allocation to trade-vulnerable industries (accounting for 11.3%) because we were unable to modify the Global Insights macro model.

Summary of Provisions Not Modeled

This modeling effort does not address all the provisions of H.R. 2454. Provisions included are:

- Clean Energy Deployment Administration;
- Allowance allocation to trade-vulnerable industries;
- Strategic allowance reserve (but annual allowance price limits are included);
- Independent cap-and-trade program for HFC emissions;
- Performance standards for activities not subject to the CO_2 cap-and-trade program;
- Distinct distribution of allowances to coal merchant plants;
- Efficiency standards for transportation equipment, and
- Effects of increased investment in energy research and development.

Senator BOXER. Thank you, Senator.

Senator Whitehouse.

Senator WHITEHOUSE. Madam Chair, I will waive my opening statement. I stand by yesterday's opening statement.

Senator BOXER. Which was so good.

Senator WHITEHOUSE. Thank you.

[Laughter.]

Senator BOXER. Thank you very much.

Senator Bond.

OPENING STATEMENT OF HON. CHRISTOPHER S. BOND, U.S. SENATOR FROM THE STATE OF MISSOURI

Senator BOND. Thank you very much, Madam Chair.

People today are talking about a new poll that shows that people want Government to take action to cut carbon emissions. Sounds like a nice idea. But it is also like asking how many people want a free lunch.

When pollsters ask the American public how much they are willing to pay to fight the emissions they claim for global warming, the results are much different. A Rasmussen poll found that 79 percent of Americans oppose paying even $100 per year more in higher taxes and/or higher utility costs to fight global warming. According to the poll, the majority of 56 percent did not want to pay a single penny to fight global warming.

And that is what I am hearing back home. It is not that Missourians do not care about the environment. We do. We have always supported measures, responsible measures, to clean up the environment. But what we do not want to do is kill jobs and raise energy taxes. What we do not want to do is strangle the economy with a deep recession.

Rural Missourians who depend on electric co-ops for power rose up to send this message. And what you see today are over 30,000 signed cards demanding that we keep power bills affordable. Thirty-thousand Missourians object to unfair proposals that would hurt the Midwest and hurt consumers in my State. They want to live with reasonable and responsible regulations, not burdensome mandates.

These are cards that were brought to my office by the Association of Missouri Electric Co-ops. The head of the Missouri Co-ops, Barry Hart, is here testifying later today. I thank him for his leadership and the sacrifices he has made to come up here. He will share with the committee how cap and trade legislation, like Waxman-Markey or Kerry-Boxer, will raise Missouri electricity rates up to 26 percent starting in 2011, 2012, and rising to 42 percent higher as soon as 2020.

Missourians do not understand why we would slap ourselves with energy taxes when it would do nothing, and I will emphasize nothing, to change world temperatures. That is what the scientists at EPA have told us. If EPA acts alone with a bill like Kerry-Boxer, it will have an impact on world temperatures almost too small to measure because China and India have already said flatly that they will not agree to strangle the growth of their economy to pull people out of poverty through mandated carbon reductions, which means not enough energy to supply the jobs they need.

America can do better. We can cut carbon emissions without raising energy taxes, killing jobs, if we go to zero carbon nuclear power, low carbon hybrid and electric transportation, advanced fuels, and wind and solar where they make economic sense. That is the path that Congress should take. That is the path that Missourians want to see.

And I thank the Chair.

Senator BOXER. OK. Thank you very much, Senator.

I am going to take my 2 minutes to respond to some of what has been said, and then we are going to get right to the panelists.

First of all, this poll is very interesting and so are all the messages you received from your constituents, which are very, very important.

But I think it is important to look at a poll, a CNN poll, which showed in April that only 44 percent of the people supported cap and trade system, which we call Pollution Reduction Investment, but cap and trade system. And now, after they have learned more about it because there have been lots of ad wars back and forth and discussions like this one we are having here that get covered, 60 percent favor it, and it has been described to them not in very glamorous terms.

It says under a proposal called cap and trade, the Federal Government would limit the amount of greenhouse gases companies could produce in their factories. If companies exceeded those, they would have to either pay a fine or pay money to other companies that produce smaller amounts of greenhouse gases. Would you oppose or favor this proposal? Sixty percent favor it.

And I am going to put in the record, I ask unanimous consent, the CNN story that goes with it. It says 60 percent of those questioned say they favor cap and trade, a Democratic sponsored plan in which the Federal Government explains it. Thirty-seven percent oppose, and it goes on to say that this comes out as the Senate Environment Committee holds a hearing on this legislation, and that this legislation includes provisions to hold down costs to consumers in certain industries.

And it says Republicans say the bill would destroy jobs and increase taxes and energy costs. But the bottom line that I found is interesting is the youth, the divide on generations, colleagues. And I see some young people in the audience. I would say the survey indicates a generational divide with 68 percent of Americans under age 50 supporting cap and trade. But those 50 and older split on the issue. And a Democratic divide there. It says that 3 in 4 Democrats back it, 6 in 10 Independents back it, but only 4 in 10 Republicans.

So, it is a very interesting situation here.

Now, I would also say I will put in the record also an analysis that shows that under our bill, 161 nuclear power plants would be developed as opposed to the Alexander plan, which is 100 plants paid for by the rate payers. And the reason is, once there is a price put on carbon, it makes nuclear much more affordable.

In addition, we have a nuclear title in the bill. Some want it more robust. Senator Carey is working with Senator Graham on just that, Senator Lieberman when it gets to the floor. But right now we have an R&D investment in nuclear waste management in our bill. We support safe and clean nuclear energy industry through provisions to support worker training, which are funded in the bill.

So, we are moving forward. I see that Senator Barrasso has arrived so——

Senator BOND. Madam Chair, may I interrupt to ask unanimous consent to have entered in the record the Rasmussen Poll which shows that 77 percent would not be willing to spend more than $100 for reducing global emissions?

Senator BOXER. Yes. And happily, our bill does not cost more than $100.

Senator Barrasso.

[The referenced CNN poll follows:]

May 5, 2009

CNN Poll: Global warming can be stopped

From CNN Deputy Political Director Paul Steinhauser

WASHINGTON (CNN) - A new national poll indicates that a majority of Americans think that global warming is real, and that the federal government can do something to slow or stop the phenomenon.

Fifty-four percent of those questioned in a CNN/Opinion Research Corporation survey released Tuesday say that global warming is occurring and that Washington can take steps to slow the rate of global warming, or eventually stop it altogether. Twenty-seven percent agree that global warming is real, but think the federal government is powerless to stop it or slow it down, and 17 percent say that global warming is not occurring.

"Two-thirds of Democrats think that the government can do something about global warming, but only a third of Republicans feel that way," says CNN Polling Director Keating Holland. "The same number of Republicans don't believe that global warming is happening at all. Only one in 20 Democrats think global warming is a myth."

The poll also suggests that a slight majority oppose a proposal called "cap and trade," which would allow the federal government to limit the emissions from industrial facilities such as power plants and factories that some people believe cause global warming. Companies that exceed the limit could avoid fines or higher taxes by paying money to other companies that produced fewer emissions than allowed. Forty-four percent support "cap and trade," which is backed by the Obama administration.

The survey's release comes on the same day that more than 30 congressional Democrats met with President Obama at the White House to discuss the issue. The president is trying to prevent progress on climate change, one of his signature issues, from being derailed by divisions within his own party over "cap and trade."

"Since more than four in ten Americans believe that the government can do nothing about global warming, a cap-and-trade proposal - or any other government action that is meant to reduce global warming - may be a hard sell," Holland says.

The CNN/Opinion Research Corporation poll was conducted April 23-26, with 2,019 adult Americans questioned by telephone. The survey's sampling error is plus or minus 3 percentage points.

Filed under: **CNN poll** · **Global Warming**

http://politicalticker.blogs.cnn.com/2009/05/05/cnn-poll-global-warming-can-be-stopped/

OPENING STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR FROM THE STATE OF WYOMING

Senator BARRASSO. Thank you very much, Madam Chairman. I know that I have only 2 minutes when I was prepared to talk a little longer. But I will tell you that I have concerns about that, and I would like to have my entire statement as a part of the record.

Senator BOXER. Yes. And you could go 3 minutes.

Senator BARRASSO. Thank you very much, Madam Chair.

Well, the warning signs are all around us that this energy tax bill is going to lead to lost jobs, higher energy prices, and I think will do very little in terms of an environmental gain. But you do not have to take my word for it. Here is an Investors Business Daily, Cap and Fade. The sub-headline is the Senate has finally rolled out its long awaited cap and trade bill to slash carbon dioxide. Looking at its Draconian restrictions on the U.S. economy, it is hard to believe its supporters are serious.

The editorial goes on to state that the Boxer-Kerry energy tax bill will take $9.4 trillion from the gross domestic product, will kill 2.5 million jobs, gasoline prices will go up, electricity rates will nearly double. The editorial concludes the only way to meet Boxer-Kerry's goal will be to push the economy into a state of permanent recession. A permanent recession.

Jim Manzi, a Senior Fellow at the Manhattan Institute, wrote in the D.C. Examiner that the House passed energy bill would be a terrible deal for American taxpayers. If the law works precisely as intended, in about 100 years we should expect surface temperatures to be about one-tenth of 1 degree Celsius lower than they would otherwise be. The expected costs to the American people are at least 10 times that of the expected benefits. So the American people are going to bear the brunt of the lost jobs and higher energy costs all for just one-tenth of 1 degree in 100 years.

The person who actually wrote the most about the cap and trade was Thomas Crocker, who is a University of Wyoming professor. He has written in the Wall Street Journal as a critic, now, of this, saying that cap and trade's flaws, if applied to climate change, and they are extensive. I think Doug Elmendorf stated, as we have heard in testimony in the Senate in the last couple of weeks, the fact that jobs turn up somewhere else for some people does not mean that there are not substantial costs, substantial costs, borne by people, communities, firms and affected industries and affected areas. We have seen this in manufacturing. We have seen it with the Rust Belt.

The warning signs are all around us. We need to heed them in terms of our economy to ensure that Americans who do not get green jobs are able to keep the red, white and blue jobs that they have and to continue to power the country.

To me, that is the way to make America's energy as clean as we can, as fast as we can, without raising energy prices on the American families.

Thank you, Madam Chairman.

[The prepared statement of Senator Barrasso was not received at time of print.]

Senator BOXER. Thank you, Senator, you are very eloquent. Those exact words almost were used by those who were fighting the acid rain cap and trade program. To the words. To the very words. And it proved completely incorrect.

So, we are going to go to the panel. I want to hold up. Since you held up a chart, we are going to have our little chart wars today. You hold up one, we hold up one. It is kind of equal time.

Senator BARRASSO. Could I have my editorial on Cap and Fade included then in the record as well since——

Senator BOXER. Without a doubt about it. Yes. Yes.

Senator BARRASSO. Thank you, Madam Chairman.

[The referenced editorial was not received at time of print.]

Senator VOINOVICH. Madam Chairman, could I have my statement also included——

Senator BOXER. Yes. The entire statement will be put in the record.

Senator VOINOVICH. And the information that we have on what this would cost——

Senator BOXER. Yes, all of your information, Senator Voinovich. Senator, anything you want. Anything you want.

Senator VOINOVICH. Wonderful. Thank you.

[The referenced information was not received at time of print.]

Senator BOXER. All right. The U.S. must seize opportunity in global clean energy markets. This is a quote from John Doerr, the venture capitalist who helped launch Google and Amazon. Now, Google is here represented. So this is not from Government people. This is from the private sector, the people who know what really makes our economy go, more than we do, if I could say.

As we sit here today, we are in danger of letting the energy technology revolution pass us by. John Doerr, venture capitalist. The global clean energy market is estimated to reach $500 billion a year by 2020. Despite early U.S. leadership, German, Spanish and Chinese firms have gained market share. U.S.-China solar manufacturing market share changed from 2001 to 2008. In 2001, we had 28 percent. China had 1 percent. In 2008, the U.S. has 6 percent and China has 29 percent. So, ladies and gentlemen, all of this talk about gloom and doom? It is correct. But it applies if we do not act.

We are going to get to our panel, and we are going to start with Peter Brehm, Vice President of Business Development and Government Relations, Infinia Corporation.

Welcome.

STATEMENT OF PETER BREHM, VICE PRESIDENT, BUSINESS DEVELOPMENT AND GOVERNMENT RELATIONS, INFINIA CORPORATION

Mr. BREHM. Thank you very much, Madam Chairman.

Chairman Boxer, Ranking Republican Inhofe and members of the committee, I am Peter Brehm, Vice President of Business Development and Government Relations for Infinia. We are headquartered in the State of Washington, and we have operations in California, Maryland, Michigan, Massachusetts and New Mexico. I represent Infinia on the Board of Directors of the Solar Energy Industries Association, which is also one of the reasons that I am here.

It is an honor to appear before you to testify on behalf of Infinia and the Solar Energy Industries Association. I would also note that we are strong supporters of BlueGreen Alliance and the Apollo Alliance, and I work quite extensively and have in the past with Mr. Reicher as well.

In the 5 minutes I will be speaking to you today, enough sunlight will shine upon the United States to satisfy America's energy needs for an entire month.

Let me first tell you a bit about my firm. Infinia has developed and manufactures the Infinia Solar System, a unique, high performance solar power system that uses a Stirling engine and a parabolic mirror to convert sunlight, which is free, into electricity, which is valuable. Our system is not a PV or solar panel-based system, but instead a unique U.S.-developed and manufactured concentrating solar power system.

Each of our Infinia Solar Systems produces 3 kilowatts of grid-quality electricity. Our systems do not consume water, which is in short supply in the West, nor do we need flat or graded ground to operate.

Notably, we manufacture here in the United States, and at a time when the auto industry is facing historic difficulties, our technology is perfectly suited to be manufactured on automobile factory lines.

I will diverge from my testimony a bit just to respond to Senator Voinovich's comments earlier. I would like to note that two of our most significant vendors, which we are very proud of, are based in Ohio, MSG Molded Fiberglass Companies, they make the fiberglass backing for our solar panels——

Senator VOINOVICH. I know them very well.

Mr. BREHM. You know them very well. They are an excellent company and they have done great work with us. Another one is Zigent Automotion Systems in Ohio, and they actually are a robotics firm, and they place our mirrors on those same panels.

And I also note that our initial Stirling engine technology was developed in cooperation and with the great assistance of the folks at NASA Glenn.

Our technology is only one of many that are being developed and in commercial use. The greatest challenge the U.S. solar industry faces is scaling up production and distribution of solar technology in order to continue to drive down prices and be on par with or below the price of traditional fossil fuels.

The outlook for solar is bright, pardon the pun, particularly if Congress levels the field by enacting strong climate change legislation. Recently, the U.S. solar industry has demonstrated remarkable growth with the annual rate of solar distributed generation installations increasing by more than 80 percent in 2008. Last year, solar produced over 8 times as much energy as in 1985, and already this year 40 percent more than last year.

This is great, but not nearly enough. More can be done, and more should be done, if the United States is going to put a serious dent in emissions of greenhouse gases.

There is a very significant potential for growth of solar energy in the United States with the price signals and incentives that could be provided this legislation.

Infinia is a growing company that currently employs over 140 people, and if a robust climate change bill is enacted, our growth rate will double. Good, high paying clean energy jobs will be created here in the United States.

We believe this climate change policy is a key step in a comprehensive national energy policy. The proposed legislation will spur tremendous demand for all renewable energy technologies. We encourage the committee to strengthen the proposed legislation to ensure that more of the demand for renewable energy technology and products will be supplied by U.S. manufacturers.

Solar energy will create thousands of jobs, install half a gigawatt of solar capacity and avoid more than 1 million tons of carbon emissions in 2009. These numbers will more than double in 2010.

With the right incentives, a fair regulatory environment and the right economic environment, there will be no limit to how much solar energy can contribute to the solution. For the solar industry, a robust climate change bill will send a clear price signal on the cost of emitting carbon, which currently has no market price other than the cost to our global environment that will be paid by our children and grandchildren. This price signal will affect long-term generational planning and project financing and may mark a paradigm shift in the Nation's energy future.

In the more immediate term, solar and other renewable energies need to receive allowances in the early years of the program in order to scale up the industry and bring down the costs so we can more effectively satisfy the [unclear] of a carbon-free clean energy. Those allowances can come from Federal deployment programs for distributed generation and utility-scale renewables and from allowances going to the States and localities for renewables.

For Infinia, it is particularly important that some of those State allowances go toward the manufacturing development of incentives for solar and other domestic renewals energy technologies. It would be a huge missed opportunity if we replaced oil imported from the Mideast with renewable energy technology from overseas.

In addition, we encourage the committee to consider the inclusion of Senator Sherrod Brown's IMPACT, Investments for Manufacturing Progress and Clean Technology, bill or similar proposals into this climate change legislation to spur the development and manufacture of renewable energy technologies in the U.S.

We believe this comprehensive legislation should include the following features. A robust cap and trade——

Senator BOXER. Mr. Brehm. Are you almost done?

Mr. BREHM. I am almost done. A Federal renewable energy standard, transmission policy, national retail net metering, and reasonable access to Federal lands.

Thank you very much.

[The prepared statement of Mr. Brehm follows:]

Testimony Of

Mr. Peter Brehm
Vice President of Business Development & Government Relations
Infinia Corporation

On Behalf Of The

Solar Energy Industries Association

At The

Committee on Environment and Public Works
U.S. Senate

Hearing On

S. 1733, Clean Energy Jobs and American Power Act

October 28, 2009

Chairman Boxer, Ranking Republican Inhofe and Members of the Committee, I am Peter Brehm, the Vice President of Business Development & Government Relations for the Infinia Corporation. We are headquartered in the State of Washington, and we have operations in California, Maryland, Michigan, Massachusetts and New Mexico, as well as Spain, India and Japan. I represent Infinia on the Board of Directors for the Solar Energy Industries Association.

It is an honor to appear before you to testify on behalf of Infinia and the Solar Energy Industries Association. In the five minutes I'll be speaking to you today, enough sunlight will shine upon the United States to satisfy America's energy demands for an entire month.

SEIA is the national trade association for the solar energy industry, and represents over 1000 member companies at all points of the value chain – from manufacturers, to solar installers, to financiers and to project developers. Established in 1974, SEIA works to make solar energy a mainstream and significant energy source in the United States by expanding markets, strengthening the industry and educating the public on the benefits of solar energy.

Let me first tell you a bit about my firm. Infinia has developed and manufactures the Infinia Solar System, a unique, high-performance solar power system that uses a Stirling engine and a parabolic mirror to convert sun light, which is free, into electric power, which is valuable. Our system is not a PV or solar panel-based system, but instead a unique U.S.-developed and manufactured Concentrating Solar Power system. Each of our Infinia Solar Systems produces 3 kW of grid-quality AC electricity. Our systems do not consume water – which is in short supply in the West – nor do they need flat or graded ground to operate. And through scalability we can size our projects to fit within existing transmission and distribution system constraints.

The result: We can provide heat and power to individual customers or supplement generation for the grid without any contribution to greenhouse gas emissions.

Notably we manufacture here in the United States and, at a time when the auto industry is facing historic difficulties, our technology is perfectly suited to being manufactured on converted automobile factory lines. In fact, virtually our entire supply chain are automobile industry suppliers, most of which are based in the hard-hit Midwest including Michigan, Ohio, Indiana and Iowa

Our solar technology is only one of many that are being developed and in commercial use.

Solar energy is the cleanest and most abundant renewable energy source available. And the U.S. has some of the richest solar resources in the world. Today's technology allows us to capture this power in several ways giving the public and commercial entities flexible ways to employ both the heat and light of the sun.

The greatest challenge the U.S. solar industry faces is scaling up production and distribution of solar technology in order to continue to drive down prices to be on par with or below the price of traditional fossil generation.

President Obama has set out a goal of doubling the Nation's renewable energy production in the next three years. A majority of States have already adopted an ambitious Renewable Portfolio Standard. But this should only be the beginning.

The outlook for solar is bright – pardon the pun – particularly if the Congress levels the field by enacting strong climate change legislation.

Recently, the U.S. solar industry has demonstrated remarkable growth with the annual rate of solar distributed generation installations increasing by more than 80% in 2008. New utility-scale solar plants have been announced in States ranging from California to Texas, Florida, Pennsylvania, New York and more, and projects totaling more than 10,000 MW are currently operational or under development.

Last year, solar energy produced 843 million kilowatt hours, as compared to less than a hundred in 1985. And for the first six months of 2009, solar produced 40 percent more electricity than in the same period in 2008.

That is great, but it is not nearly enough. More can be done and more should be done if the United States is going to put a serious dent in emissions of greenhouse gasses.

There is a very significant potential for growth of solar energy in the United States with the price signals and incentives that could be provided by this legislation. A study conducted by the Department of Energy for the Western Governors' Association determined that the seven States in the Southwest have a combination of solar resources and available suitable land to generate up to 6,800 GW of electricity. This compares to today's nameplate capacity for all electricity generation in the U.S. of 1,000 GW. If you add the solar potential from the other States, the resource available is functionally limitless.

Infinia is a growing company that currently employs over 140 people, and if a robust climate change bill is enacted our growth rate will double with commensurate increases in employment. This will be the case at solar companies across the country. Good, high-paying clean-energy jobs will be created here in the United States.

We believe this climate change legislation is a key step in a comprehensive energy policy. The proposed legislation will spur tremendous demand for all renewable energy technologies.

For Infinia, I would note the importance of promoting U.S. development and manufacturing of renewable energy technology and products. We encourage the Committee to strengthen the proposed legislation to ensure that more of the demand for renewable energy technology and products will be supplied by U.S. manufacturers.

Solar energy will create thousands of jobs, install half a gigawatt of solar capacity and avoid more than 1 million tons of carbon emissions in 2009 alone. These numbers will more than double in 2010.

We commend the sponsors of S. 1733 – Senators Kerry, Boxer and Kirk – for recognizing that solar energy and other renewables can and must be an integral part of any solution to global climate change.

With the right incentives, a fair regulatory environment and the right economic environment, there is no limit to how much solar energy can contribute to the solution.

For the solar industry, a robust climate change bill will send a clear price signal on the cost of emitting carbon, which currently has no market price other than the cost to our global environment that will be paid by our children and grandchildren. This price signal will affect long-term generation planning and project financing, and mark a paradigm shift in the nation's energy future.

In the more immediate term, solar and other renewables need to receive allowances in the early years of the program in order to scale up the industry and bring down costs so that we can more effectively satisfy the wedges of carbon-free energy.

Those allowances can come from a federal deployment programs for distributed generation and utility-scale renewables and from allowances going to the States and localities for renewables.

For Infinia, it is particularly important that some of those State allowances go toward technology development and manufacturing incentives for solar and other domestic renewable energy technologies. It would be a huge missed opportunity if we replaced oil imported from the Mideast with renewable energy technology from oversees.

In addition, we encourage the committee to consider the inclusion of Senator Sherrod Brown's IMPACT (Investments for Manufacturing Progress and Clean Technology) bill or similar proposals into this climate change legislation to spur the development and manufacturing of renewable energy technology in the U.S.

For the solar industry as a whole, it is crucial that allowances be dedicated for the deployment of all solar technologies, with direct allocations making their way to solar generators. This will act as a catalyst to the industry, directly spur deployment of renewables, and help protect the voluntary renewables markets.

This climate legislation should also move in unison with the energy bill, to comprehensively address the energy needs of the nation. We believe that this comprehensive legislation should include the following key features:

- A robust cap-and-trade program that provides real incentives for all renewable energy types, including solar.

- A strong and diverse federal renewable energy standard.

- Transmission policy reform.

- Interconnection standards and a process that provides clear, simple and reasonable specifications for a homeowner, business or installer to connect to the local utility's distribution system.

- National retail net metering standards that allow customers who generate more solar energy than they consume to sell the excess electricity back to their local utility.

- Reasonable access to Federal lands for solar projects and other renewable technologies on par with the access granted for other uses of the land, including fossil and mineral extraction.

We recognize that not all of these matters are within the jurisdiction of the Committee on Environment and Public Works, however S.1733 is a crucial part of the whole.

We strongly urge the Committee to move forward with this legislation, report it to the full Senate, incorporate provisions on the Senate floor from other committees of jurisdiction, such as the Finance Committee and the Energy Committee – and get this legislation enacted NOW.

In closing let me reiterate the key benefits of solar technology.

- ➢ Solar energy is a reliable domestic source of energy and is much less vulnerable to supply disruptions from foreign actions, natural disasters or grid instability.
- ➢ Solar technologies generate energy during peak hours of demand, when energy is in short supply and most expensive.
- ➢ Solar systems require high-tech manufacturing facilities and produce well paying, high-quality jobs.
- ➢ Solar energy is the cleanest of all energy sources, producing electric and thermal energy with zero emissions and no waste products or other forms of pollution.
- ➢ Solar energy technologies use a free, inexhaustible fuel source and therefore provide price stability for decades.

With your leadership, we can have a brighter and cleaner tomorrow. The time to act is now.

Thank you for allowing me to testify both on behalf of my company Infinia and the Solar Energy Industries Association.

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Response by Peter Brehm
to Senator Klobuchar's Question from the
U.S. Senate Environment and Public Works Committee
Hearing of October 28, 2009

Question by Senator Amy Klobuchar

In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy - from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?

Answer:

The importance of this legislation cannot be overstated as it will be the foundation from which all the other related policies and programs (energy, tax, domestic manufacturing incentives, R&D incentives, etc.) will be built. As such, it is very important that this policy be long term, send clear price signals to the market and be flexible enough to promote and encourage complementary energy, tax, domestic manufacturing and R&D policies and programs (the cap and trade concept is inherently a flexible policy as it adapts to price signals and other externalities over time). The need for a visible and long term policy can also not be understated. The most notable example is what happened to the wind industry. The inconsistent U.S. wind policies, programs and incentives literally drove the manufacturing of wind turbines and the related supply chain overseas. The U.S. developed and perfected utility-scale wind power but now we are trailing the rest of the world (4^{th} or 5^{th} place) in wind turbine manufacturing. Not only have we already dropped to 4^{th} or 5^{th} place, but the leading U.S. manufacturer is losing market share.

Passage of the climate change legislation will help address these challenges. It will provide a very important and consistent signal to the marketplace that will effectively incent the use of renewable energy technologies like solar, wind, biomass and other clean energy technologies. The carbon price established by the cap and trade credit market will encourage utilities and individuals to invest in, and deploy, renewable energy technologies, since their relatively carbon-free characteristics will make them relatively more economic in the future. Moreover, by setting aside allowances from under the cap for renewable energy, the legislation creates an additional incentive that will further encourage deployment of these carbon-free technologies. Infinia is particularly interested in seeing some of the state allocation for renewable energy used for domestic manufacturing of renewables, which we believe will help create a stable environment for job creation in the U.S. Solar power and other renewables represent an enormous opportunity over the next few decades to reduce greenhouse gas emissions and create American jobs. As a result, many of us in the renewable energy industries are hopeful that Congress will enact cap and trade legislation in the foreseeable future.

Senator BOXER. Very good. Thank you very much.

Dan Reicher, Director, Climate Change and Energy Initiatives at Google.

Welcome.

STATEMENT OF DAN W. REICHER, DIRECTOR, CLIMATE CHANGE AND ENERGY INITIATIVES, GOOGLE

Mr. REICHER. Chairman Boxer and members of the committee, my key message today is that the critical need to address the climate crisis provides us with an unprecedented opportunity to rebuild our energy system with vast economic security and environmental benefits.

By putting significant limits on carbon emissions and adopting strong, complementary energy policies, we can create millions of new jobs, reduce our dangerous dependence on foreign energy, and protect ourselves from a global climate crisis.

Google published a scenario last year called Clean Energy 2030, which outlines one potential path to a clean energy future. In sum, the Clean Energy 2030 proposal reduces U.S. CO_2 emissions about 50 percent below the baseline projection while creating 9 million new jobs and net savings of $800 billion.

At the global level, the International Energy Agency estimates that between 2007 and 2030, the world will need to invest $26.3 trillion in energy infrastructure to meet currently projected energy demand. As venture capitalist John Doerr has also said, this massive global energy spending could make clean energy technology the biggest economic opportunity of the 21st century.

The ability of the U.S. to seize this historic economic opportunity will be influenced to a large extent by actions taken by Government to put a significant price on carbon emissions. But a significant price on carbon, while absolutely necessary, is not sufficient to address the climate problem, and importantly, will not put the U.S. in position to seize the extraordinary opportunities that will come with rebuilding the global energy economy.

My primary focus today is on four complementary energy policy mechanisms that will be essential to taking advantage of these opportunities.

First, we must significantly increase public funding of research and development of advanced energy technologies. In 1980, 10 percent of the total government R&D investment was in energy. Today, it is only 2 percent. The Federal stimulus package has certainly provided a shot in the arm for clean energy projects, but there is a serious risk of falling off a funding cliff when these investments run out.

We were encouraged when President Obama called for investing $15 billion per year over the next decade in clean energy technologies and took note when Secretary Chu said that energy R&D spending must move closer to the level in the high tech industry, which are generally around 10 percent of sales.

A failure to invest, Madam Chairman, becomes glaringly apparent when we realize that barely a fifth of the top 30 manufacturers of wind turbines, solar panels and advanced batteries are American. In contrast, all 5 of the world's leading Internet technology companies are from the U.S. And the Internet itself was the product of federally funded R&D work by DARPA in the 1970s.

Second, we must increase the capital available to deploy these advanced technologies at commercial scale. Moving from a Nation that derives 70 percent of its power from fossil technologies to one based largely on clean energy will require literally trillions of dollars of investment.

The challenge is that raising this kind of a capital, especially for innovative technologies, is not easy. The problematic step of moving a technology from a small pilot project often funded by venture capital to full commercial-scale projects financed largely by the banks is frequently the point at which many promising energy technologies die. Indeed, we call it the Valley of Death.

At Google, we are major supporters of pending bipartisan Senate legislation that would create a Federal Clean Energy Deployment Administration to provide various types of credit support to drive private investment in Valley of Death projects. CEDA would be an independent administration within DOE with a Senate-confirmed administrator and board of directors.

Third, we must build a bigger and smarter electric grid to harness energy efficiency and renewable energy. A smarter grid will let us see our energy use, measure it, price it, and manage it to get the most out of every watt. And a bigger grid will allow us to tap our Nation's vast clean energy resources and deliver them where we need them.

At Google, we are working to advance the smart grid on several fronts. Among these, our engineers have developed a simple secure and free software tool called Google Power Meter that gives consumers an easy means to see their home electricity on their computer or smart phone.

Fourth and finally, we must set national standard to accelerate the uptake of clean air and more efficient technologies. Google supports the adoption of both a strong national energy renewable standard and a strong national energy efficiency resource standard. State renewable energy and energy efficiency standards have sparked new industries and created thousands of jobs.

Before I wrap up, let me mention two examples of where a price on carbon and complementary energy policies can be catalytic. One is solar thermal power, where early on DOE-funded demonstration projects proved the technology and where today State renewable standards are driving demand and Government-backed finance is helping plants get built.

Looking ahead, an advanced geothermal energy technology called EGS presents another opportunity where a strong energy policy and a price on carbon could drive a new industry that could produce cheap, renewable power 24 hours a day year round and nationwide.

In conclusion, let me stress that we need both a significant price on carbon and complementary energy policies. A significant price will definitely send a signal about the need to reduce carbon emissions, but it will not by itself ensure that the technologies that can address the problem are invented and deployed here in the U.S. with massive resulting economic and security benefits.

And while smart energy policies can strongly advance solutions to the climate crisis, they will not ensure that these solutions can compete straight up with fossil fuels without a significant carbon price.

Thank you.

[The prepared statement of Mr. Reicher follows:]

Testimony of Dan W. Reicher
Director, Climate Change and Energy Initiatives
Google
before the Senate Committee on Environment and Public Works
Legislative Hearing on S. 1733
Clean Energy Jobs and American Power Act
October 28, 2009

Introduction

Chairman Boxer and members of the committee, my name is Dan Reicher and I am pleased to share my perspective on legislation to address climate change and build a clean energy future. I serve as Director of Climate Change and Energy Initiatives at Google. At Google we have been working to lower the cost and increase the deployment of renewable energy through our Renewable Electricity Cheaper than Coal (RE<C) Initiative and also to accelerate the deployment of plug-in vehicles through our RechargeIT Initiative. We have also developed a product called Google PowerMeter which facilitates monitoring of home energy use. We pursue these various initiatives through engineering, investment, and policy and also apply the broad range of Google's information tools including Google Earth, Google Maps and YouTube. Google engineers have also been working for nearly a decade to optimize the efficiency of our data centers. And we are focused on increasing the sustainability of our offices in both the U.S. and other countries as well as using on-site renewable energy.

Prior to my position with Google, I was President and Co-Founder of New Energy Capital, a private equity firm funded by the California State Teachers Retirement System and Vantage Point Venture Partners to invest in clean energy projects. Prior to this position, I was Executive Vice President of Northern Power Systems, one of the nation's oldest renewable energy companies. Prior to my roles in the private sector, I served in the Clinton Administration as Assistant Secretary of Energy for Energy Efficiency and Renewable Energy, the Acting Assistant Secretary of Energy for Policy, and Department of Energy Chief of Staff and Deputy Chief of Staff.

I also am a member of the National Academy of Sciences Board on Energy and Environmental Systems. I testified earlier this year in the Senate Energy Committee on a key provision of the Committee's pending American Clean Energy Leadership Act (ACELA) and in the House Energy and Commerce Committee on the American Clean Energy and Security Act (ACES). Recently I served on President Obama's transition team where I focused on the development of the stimulus package for clean energy.

I want to thank Chairman Boxer for her outstanding leadership on the climate issue and the impressive piece of legislation that we are focused on at this hearing: *S. 1733, The Clean Energy Jobs and American Power Act.*

An Unprecedented Opportunity

My key message today is that the critical need to address the climate crisis provides us with an unprecedented *opportunity* to rebuild our energy system with vast economic, security and environmental *benefits*. By putting serious limits on carbon emissions – and adopting strong complementary energy policies – we can help advance several critical priorities:

- **Create millions of new domestic jobs in 21st century industries**

- **Reduce our dangerous dependence on foreign energy supplies**

- **Protect us from a global climate crisis**

Aggressive federal policy can drive private sector investment – measured in the *trillions* of dollars – that will be required to move the nation and the globe toward a more sustainable energy future. We have a real opportunity to transform our economy from one running primarily on fossil fuels to one based largely on clean energy. Technologies and know-how to accomplish this are either available today or are under development. We can build whole new industries and create millions of new jobs. We can cut energy costs, both at home and at the gas pump. We can improve our national security. And we can confront climate change. With serious and timely limits on climate emissions – and complementary energy policies -- we can offset the significant costs of rebuilding our energy infrastructure with real economic gains and job creation.

Google published a scenario in the fall of 2008 called *Clean Energy 2030*, which outlines one potential path to weaning the U.S. off of coal for electricity generation and cutting oil use for cars by more than 40%. *Altogether the Clean Energy 2030 proposal reduces US CO2 emissions about 50% below the baseline projection, while creating 9 million jobs and doing so with net savings of $800 billion.* Importantly, under the *Clean Energy 2030* Plan, investment in energy-efficient technology would keep electrical demand flat at the current level rather than allowing it to grow 25% as currently projected.

Having kept demand flat with efficiency, *Clean Energy 2030* proposes gradually replacing coal and oil for electricity generation with wind, solar, geothermal, biomass, and hydropower. By 2030, about 68% of generation would come from these sources, with continuing use of nuclear power and natural gas. In the personal vehicles sector, by increasing fuel efficiency in conventional cars to 45 mpg, and massive deployment of plug-in electric vehicles, we would reduce fuel consumption 44% relative to the baseline, and dramatically cut oil imports. Together, these changes would reduce CO2 emissions in 2030 enough to move the nation about halfway to the 83% by 2050 greenhouse gas reduction goal in the bill we are reviewing today. Such a massive build-out of electric generation capacity, efficiency improvements, and plug-in vehicles would cost $3.9 trillion, but save $4.7 trillion from avoided fossil generation capacity, and lower electricity and fuel costs.

A study in this month's Scientific American by Mark Jacobson at Stanford and Mark Delucchi at the University of California Davis moves a step beyond the Google scenario. Professors Jacobson and Delucchi chart a path to a world in 2030 powered *100%* by renewable energy, concluding that such a system would not only be technically but also economically feasible.

Considering global energy use, the International Energy Agency estimates that between 2007 and 2030, the world will need to invest $26.3 trillion in energy supply infrastructure across the economy to meet currently projected demand. As the venture capitalist John Doerr has said, global energy spending "is the mother of all markets," and one that could make clean technology "the biggest economic opportunity of the 21st century."

Chairman Boxer, the ability of the US to seize this historic economic opportunity will be influenced, to a large extent, by decisions made by Congress and the Administration. There is an array of actions available to secure these kinds of benefits. Foremost among them is to put a significant price on carbon emissions and do so quickly in order to internalize the costs of climate change and move energy investments toward more efficient and lower carbon technologies.

But let me emphasize that putting a price on carbon, while absolutely necessary, is not sufficient to address the climate problem and, importantly, will not put the US in the position to seize the extraordinary opportunities that will come with rebuilding the global energy economy. My primary focus today is on the complementary energy policy mechanisms that are critical to securing dramatic reductions in greenhouse gas emissions and the broad range of accompanying economic, security and environmental benefits. Some of them have been addressed by the Senate Energy and Natural Resources Committee in the American Clean Energy Leadership Act (ACELA) and by the House of Representatives in the American Clean Energy and Security (ACES) Act. In this testimony I review four of the most important mechanisms. In brief:

- **We must significantly increase public funding of research and development of advanced energy technologies**

- **We must increase the capital available to deploy these advanced technologies at commercial scale**

- **We must build a smarter and bigger electric grid to better harness energy efficiency and renewable energy**

- **We must set national standards to accelerate the uptake of cleaner and more efficient technologies**

I conclude the statement with two examples -- involving solar thermal and advanced geothermal energy -- of how these policy mechanisms, working together, can help accelerate the shift to clean energy. Before I review these important policy mechanisms let me make three important points.

First, at Google we believe that ultimate success in solving the climate problem will largely be measured by our ability to move innovations in clean energy technology along the pathway from early research to development and demonstration to cost competitive commercial deployment. We feel strongly that each step along the way needs significant policy support – both push and pull mechanisms – from increased R&D funding and project finance to a better electric grid and aggressive clean energy standards. And all of this must be built on a critical foundation – a serious price on carbon emissions.

Second, let me stress that we need *both* a serious price on carbon *and* complementary energy policies. A serious price will definitely send a signal about the need to reduce carbon emissions but it won't, by itself, ensure that the technologies that can address the problem are invented and deployed here in the US – with massive resulting economic and security benefits. And while smart energy policies can strongly advance solutions to the climate crisis, they will not ensure that these solutions can compete straight up with fossil fuels – without a serious price on carbon.

Third, it should go without saying but success in confronting climate change will require a *global* commitment to cutting emissions, involving nations across the planet. The US must take a major step itself but reductions at the level required to address the problem will require a concerted effort among many countries, driven by strong international agreements.

Expanding Clean Energy R&D

To successfully confront the climate crisis – and secure the associated economic and security benefits – we must nurture the seed corn that leads to further technological breakthroughs in clean energy. From energy efficiency and renewable energy to advanced nuclear and fossil technologies, we need to greatly accelerate US energy R&D efforts. Unfortunately, no matter how you measure it, U.S. government investment in clean energy R&D is woefully inadequate. Today federal energy R&D expenditures are just one-fifth of their 1980 peak as a percentage of GDP. In contrast, Japan has kept a steady investment in energy research and actually outspent the US as of 2004. And China is rapidly increasing energy R&D spending as well.

Our failure to invest becomes glaringly apparent when we realize that of the top five manufacturers of wind turbines only one is American and further that the US is home to only one of the 10 biggest solar panel producers in the world and only two of the top 10 advanced battery manufacturers. In contrast, all five of the world's leading Internet technology companies – Amazon, eBay, Google, Microsoft and Yahoo – are American. The Internet itself, was the product of federally funded R&D work by the DARPA in the 1970's. In 2007, electronic commerce made possible by the Internet, contributed over $3.3 trillion to the U.S. economy.

Since 1980 U.S. federal investment in energy R&D has dropped by 58 percent. At that time, 10 percent of the total government R&D investment was in energy. Today, the percentage has shrunk to only two percent. The federal stimulus package has certainly provided a much needed shot in the arm for US clean energy programs and projects but there is a clear risk of falling off a "funding cliff" when these investments run out and we return to the normal appropriations process.

We were encouraged when President Obama, in his February budget address, called for investing $15 billion per year over the next decade to develop clean energy technologies. And this Spring, in a speech at MIT, Energy Secretary Chu said that to address the climate crisis energy R&D spending must move closer to the levels of the high-tech industry, which are generally around 10 percent of company sales. Some experts go even further. Professors Dan Kammen and Gregory Nemet at the University of California Berkeley, propose that annual energy R&D levels up to and exceeding $30 billion will be necessary to address the climate challenge, a view shared by the Brookings Institution.

There is a view that somehow the private sector will fill the serious gap that exists today in energy R&D. First, energy companies large and small are cutting not expanding their research budget. Second, university research budgets have been hit hard in the recent recession. And third, while venture capital investment has helped address the R&D shortfall, by its nature this kind of funding is more at the applied end of R&D where a commercial "exit" has serious promise. The high risk early stage research funded by government that has brought us major breakthroughs in biotech, information technology, and energy is generally not the province of venture investment.

The CEJAPA has only a brief energy research subtitle with no specific authorization and there are scattered additional R&D programs such as one to address the reliability, aging, security and other aspects of nuclear power. The Senate Energy Committee's American Clean Energy Leadership Act would double the authorization level of the Department of Energy's energy R&D program from $3.28 billion in fiscal year 2009 to $6.56 billion in fiscal year 2013. This is a start but a long way from the President's plan. The House of Representatives in the ACES bill has also not stepped up fully.

As a result of this serious energy R&D funding gap, 34 Nobel laureates recently wrote to President Obama asking him to press Congress to adopt legislation that would fund clean energy R&D at an amount approaching the level he proposed in February. The Nobel laureates stressed that funding at this level "is essential to pay for the research and development needed if the U.S., as well as the developing world, are to achieve their goals in reducing greenhouse gases at an affordable cost." And they went on to emphasize that "stable R&D spending is not a luxury, it is in fact necessary because rapid scientific and technical progress is crucial to achieving these goals, and to making the cost affordable."

Chairman Boxer, it is essential that Congress address this serious energy R&D short-fall by incorporating President Obama's goal of $15 billion per year in federal energy R&D spending in final climate legislation.

Increasing Access to Capital for Clean Energy Deployment

Beyond support for R&D, federal climate and energy legislation must directly address a critical issue in advancing our clean energy economy: increasing access to capital to deploy clean energy projects essential to meet our climate goals. Moving from a nation that derives 70% of its power from fossil technologies to one where low carbon technologies provide the lion's share of electricity will require literally trillions of dollars of investment in generating plants and transmission infrastructure. Renewable energy projects often need more construction capital upfront than traditional energy projects but less operating capital down the road because fuel is free. The challenge is that in bad times – as well as good – raising this kind of capital, especially for innovative technologies is not easy.

From an economic competitiveness perspective we should also address this issue. In a number of cases clean energy technologies invented in the U.S. have failed domestically but succeed in foreign markets with more supportive commercialization policies. Our nation often finds itself in the peculiar position of purchasing technologies such as wind turbines, solar panels, and solar thermal plants originally invented in the United States from foreign companies who have advanced past their U.S. competitors.

At Google we've been major supporters of pending Senate legislation that would create a federal Clean Energy Deployment Administration – or CEDA – to spur private investment in innovative clean energy projects. The primary CEDA mission, as proposed by Senators Bingaman and

Murkowski – and contained in the Senate Energy Committee's American Clean Energy Leadership Act (ACELA) -- would be to encourage deployment of clean energy technologies that are perceived as too risky by commercial lenders but with high potential to address our environmental, economic and security challenges.

The problematic moment of moving a technology from a small pilot project to a full commercial-scale plant is often the point at which many promising energy technologies falter – and a significant number die. In the clean energy technology industry we call it the "Valley of Death". Valley of Death projects sit precariously between the venture capital and project finance worlds. They are generally too big in terms of required capital and too small in terms of returns for the venture capital community. And they are often too risky for the project finance players, especially for the banks that typically provide the great majority of a project investment.

CEDA would use a portfolio investment approach in order to mitigate risk and also work to become self-sustaining over the long term by balancing riskier investments with revenues from other services and less risky investments. CEDA would provide various types of credit to support deployment of clean energy technologies including loans, loan guarantees and other credit enhancements as well as secondary market support to develop products such as clean energy-backed bonds that would allow less expensive lending in the private sector. CEDA would also assume responsibility for DOE's current loan guarantee program. CEDA would be an independent administration within DOE, like the Federal Energy Regulatory Commission. It would be governed by a Board of Directors and an Administrator, all of whom would be appointed with the advice and consent of the Senate. CEDA will also have a permanent Technology Advisory Council to advise new technologies.

Chairman Boxer, it is essential that Congress establish a public mechanism like the Clean Energy Deployment Administration to spur private investment in higher risk innovative clean energy projects.

Building a Smarter and Bigger Electric Grid

A smarter and bigger electric grid is also critical to advancing – and seizing the benefits of – a clean energy economy. A *smarter* grid will let us "see our energy use, measure it, price it and manage it in a way that lets us cut waste and get the most out of every watt." (*Smart Grid Briefing Document,* Foundation Capital). And a *bigger* grid will allow us to tap our nation's vast clean energy resources – wind in the midwest, solar in the southwest, geothermal in the west and gulf coast, biomass in the southeast – and deliver them where needed.

The compelling aspect of the smart grid is that like the Internet it will enable multiple applications – real time energy measurement, energy efficiency management, grid support capabilities – to operate over a shared interoperable network. Like the Internet, the smart grid is a core technology that can help revitalize our economy. And as with the Internet the government has an essential role in setting the policy framework and providing the incentives that will encourage a smart grid.

At Google we are working to advance the smart grid on several fronts:

First, over the last year, our engineers have developed a simple and secure software tool called Google PowerMeter. This free software product gives consumers an easy means to draw data regarding their home electricity use – from a smart utility meter or other simple device – and see it on their computer, smart phone or an in-home display. With it comes the opportunity for significant reductions in home energy use, an important element of cost-effective implementation of climate legislation.

Second, we have developed a fleet of plug-in hybrid-electric vehicles that have provided significant public data on fuel efficiency under driving conditions that simulate common US driving patterns. We have also worked on "smart charging" of plug-in vehicles, with a particular focus on how large numbers of plug-in cars can be effectively integrated into the electric grid in a way that actually stabilizes the grid and enables a greater share of renewable generation.

Third, we are exploring how we might accelerate the integration of smart appliances and other equipment to cut energy use and reduce peak load.

Overall, we believe:

- **We need to develop the smart grid in a way that spurs innovation, drives competition, and supplies maximum information to consumers.**

- **We must develop and deploy smart grid technology in a manner that empowers consumers with greater information, tools and choices about how they use electricity, including access to real-time energy information.**

- **And energy information should be made available based on open non-proprietary standards to spur the development of products and services to help consumers save energy and money.**

The 2007 Energy Independence and Security Act (EISA) took a number of steps to advance the development of a smarter US grid. The House ACES bill takes this further with measures, for example, to develop home appliances with the capability to interact with the grid, and, through FERC, to reform regional planning to modernize the electric grid. The CEJAPA includes some helpful additional provisions including Section 201 that would establish a Clean Vehicle Technology Fund to back the deployment of plug-in vehicles and the electrical infrastructure to support them, and Sections 202-204 that would provide emissions allowances to states, local governments, tribes and others to support smart grid development.

Beyond building a smarter grid we also need to build a bigger grid. The lack of transmission capacity to move electricity from where it is generated to where it is used is a major constraint on the accelerated deployment of clean energy technologies to meet our climate, economic and security goals. *The nation's transmission grid is in serious need of modernization to enable massive deployment of renewable electricity and other advanced technologies.* Significant new transmission capacity must be built if we are going to tap, for example, the vast wind resources of the midwest and the solar resources of the southwest. At the same time, we must ensure that all potentially cost-effective alternatives to new transmission lines are fully addressed in public planning processes, and that siting decisions take full account of environmental values and constraints.

The CEJAPA includes improvement in transmission capacity among the uses of emissions allowances for states, local governments, tribes and others under sections 202-204. In the American Clean Energy Leadership Act, the Senate Energy Committee included some important provisions designed to improve regional or interconnection-wide transmission planning for high-priority national transmission projects, including the high-voltage lines necessary to connect renewable energy resources to demand centers.

The National Commission on Energy Policy, a bipartisan group of energy experts, has recently proposed a number of measures to strengthen the existing transmission-related provisions in the Senate Energy Committee bill. We would highlight two areas in particular. First, FERC "backstop authority" can advance the siting of critical transmission infrastructure that has been stalemated by local or state disputes, undermining the broader national interest. Second, we need clear and consistent methods to allocate costs of new high-priority national transmission projects across the broad regions that enjoy the benefits of access to domestic, low-carbon resources.

Chairman Boxer, it is essential that Congress drive the development of a bigger and smarter electric grid.

Setting National Standards for Clean Energy

A final energy policy mechanism that could drive massive clean energy deployment involves national renewable energy and energy efficiency standards. Google strongly supports the adoption of a strong national renewable energy standard (RES), following the lead of 28 states that have already set such requirements. Google also strongly supports the adoption of a strong Energy Efficiency Resource Standard (EERS) which could be a compelling complement to an RES by significantly cutting electricity demand and thereby lowering the investment needed for broad-scale deployment of renewables.

An RES is an important tool for accelerating renewable energy technology development, lowering energy costs for consumers, reducing harmful carbon emissions, and improving energy security. Portfolio requirements like the RES provide clear market signals for policy makers, utilities, investors, researchers and entrepreneurs. Existing state requirements have definitely promoted renewables, but a national standard – designed and implemented well – could do much more to increase renewables deployment and at lower cost.

An EERS is also an important tool for advancing our clean energy objectives. Under an EERS suppliers would be required to obtain energy savings from customer facilities and distributed generation installations in amounts equal to designated percentages for base year energy sales for electricity and natural gas. Eligible energy savings measures include efficiency improvements to new or existing customer facilities, combined heat and power systems, and recycled energy from a variety of defined commercial and industrial energy applications. The EERS builds on policies now in place in a number of states including California, Texas, Pennsylvania, Colorado, Connecticut, Nevada, Vermont, and Hawaii.

The EERS and RES are compelling complements. An EERS moderates demand growth so that RES targets can actually reduce fossil fuel consumption. In the Google Clean Energy 2030 Plan, energy efficiency deployment reduces projected electricity demand 33%. This is equivalent to about 175,000 megawatts of coal generation. By moderating demand growth through an EERS and accelerating clean generation through an RES, we can slow and begin to decrease carbon emissions in the utility sector, while we work to implement a comprehensive cap-and-trade system.

State RES and EERS policies have sparked entire new industries and created thousands of jobs. National standards could produce much more. But we should avoid setting standards so weak that they simply replicate business as usual. We need RES and EERS provisions that stimulate significant new development of clean energy projects involving a broad array of technologies and putting us on an accelerated path to significant carbon reductions.

The Senate Energy Committee's American Clean Energy Leadership Act establishes a combined renewable energy and energy efficiency target of 15% by 2020. The Union of Concerned Scientists estimates that existing state Renewable Portfolio Standards will result in at least 11% renewables by 2020 and the American Council for an Energy-Efficient Economy has estimated that existing state energy-efficiency requirements and efforts will achieve 5% energy efficiency savings by 2020. Thus, current efforts for renewables and efficiency exceed the Senate targets and these targets could very well have no effect. The House climate bill is a little better, with a combined renewable and efficiency 2020 target of 20% of electricity sales. We recommend that the final Senate climate bill raise the efficiency and renewable energy targets substantially above the current 15% level in the current Senate Energy Committee bill.

Beyond an RES and EERS, the CEJAPA has the potential to greatly incentivize efficiency and renewables through the allowance process. *We believe that substantial emissions allowances should be provided for energy efficiency and renewable energy investments, as these investments save or produce energy for many years.* The Waxman-Markey bill makes a good start by providing about 10% of allowances to states for energy efficiency and renewable energy programs, and by requiring that natural gas utilities spend one-third of their free allowances on energy efficiency. These provisions should be continued in the Senate bill and a similar provision should be added requiring electric utilities to spend one-third of their free allowances on energy efficiency.

Chairman Boxer, it is essential that Congress adopt a national RES and EERS, and ensure a significant allocation of climate emission allowances to incentivize efficiency and renewables.

Putting It All Together

A serious price on carbon along with strong complementary national energy policies – increased federal support for clean energy R&D and finance, a bigger and smarter electric grid, and an array of national clean energy standards – could accelerate dramatically the development and deployment of clean energy technologies on a massive scale. This would be a real boon to a range of clean energy opportunities – from efficiency and renewables to fossil and nuclear.

There are some solid examples of how this works. One is solar thermal, the technology that uses mirrors to concentrate the sun's heat to make steam and produce electricity at utility scale. To a large extent it was DOE-funded RD&D that proved the solar thermal concept in a set of early demonstration projects. More recently government-backed finance is helping utility-scale US plants get built. Demand for the projects is being driven by state renewable energy standards. And without an expanding network of transmission lines, moving the vast solar resource from deserts to cities would not be possible.

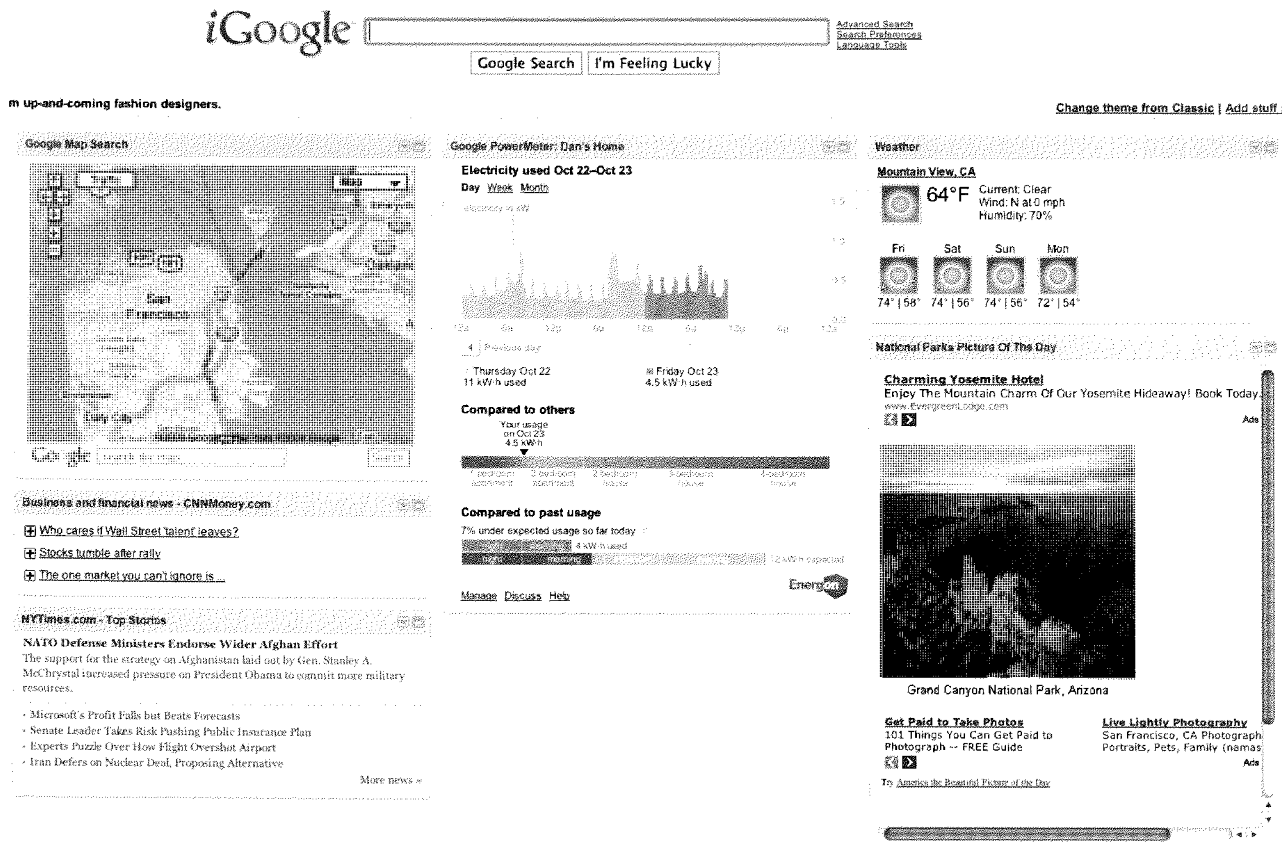
Looking ahead, an advanced geothermal energy technology called Enhanced Geothermal Systems (EGS) presents another opportunity where strong energy policy – and a price on carbon – could drive a high potential new industry. EGS has the potential to produce cheap, renewable, baseload generation 24 hours a day, year-round and nationwide, directly replacing coal capacity on the grid. With EGS, geothermal reservoirs can be "manufactured" to very large scale. While naturally existing geothermal reservoirs are relatively limited and concentrated in the Western U.S., high temperature rock capable of supporting power production with EGS is massive and nationwide.

A 2007 M.I.T. study found EGS to be a highly promising technology, concluding that just 2% of the heat below the continental U.S. between 3 and 10 kilometers depth is equivalent to over 2,500 times total U.S. annual energy use. At Google we have taken several steps to help advance EGS including making Google Earth maps of state EGS resources, supporting EGS-related technologies, helping to advance federal policy, and raising public awareness of the technology. EGS could benefit greatly from the spectrum of policies we've addressed in this testimony – increased R&D funding and clean energy finance to advance the technology; a more robust grid to get the electricity to market; and a national renewable energy standard to stimulate demand – and all of this put in place in with a serious and timely price on carbon emissions.

These are just two examples where a price on carbon *and* complementary energy policies could catalyze transformative energy technologies. There are many other technologies like them today and, excitingly, many more to be developed!

Conclusion

Chairman Boxer, we are convinced that climate change – an unprecedented crisis of global dimensions – can also provide an economic opportunity of vast proportions. The decisions made in Washington, D.C. on the policy front will greatly determine how much of this opportunity is brought home for the benefit of the citizens of our nation. At Google we stand ready to help develop and advance the energy policies that could allow our nation to seize this opportunity.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Your usage on Oct 23 4.5 kWh
Compared to past usage
7% under expected usage so far today
4 kWh used
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morning
Manage Discuss Help
Weather
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Current: Clear
Wind: N at 0 mph
Humidity: 70%
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October 30, 2009

From: Dan Reicher, Director, Climate Change and Energy Initiatives, Google
To: Senate Committee on Environment and Public Works
Re: Answers to Questions by Senators Klobuchar, Inhofe and Alexander

Questions from:

Senator Amy Klobuchar

1. In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy -- from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony today, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?

Answer: The bill will create certainty concerning finally putting a price on carbon, which will create a strong incentive for private sector markets. Putting a serious price on carbon along with strong complementary national energy policies – increased federal support for clean energy R&D and finance, a bigger and smarter electric grid, and an array of national clean energy standards – could accelerate dramatically the development and deployment of clean energy technologies on a massive scale. This would be a real boon to a range of clean energy opportunities – from efficiency and renewables to fossil and nuclear.

2. Mr. Reicher, the biggest economic engine of recent decades has been the widespread adoption of the internet, which has increased productivity and revolutionized the way we interact. Yet this incredible innovation was developed by government funded programs at the Department of Defense and the National Science Foundation. Can the development of a clean energy economy come purely from the efforts of the private sector? How can the government and private sector best cooperate to promote development of new technologies?

Answer: Although the private sector will make most of the investments needed to transition us to a new energy economy, the government has an important role to play -- particularly with regard to research and development. There is a serious gap in energy R&D that calls for government involvement. First, energy companies large and small are cutting not expanding their research budget. Second, university research budgets have been hit hard in the recent recession. And third while venture capital investment has helped address the R&D shortfall, by its nature this kind of funding is more at the applied end of R&D where a commercial "exit" has serious promise. The high risk early stage research funded by government that has brought us major breakthroughs in biotech, information technology, and energy is generally not the province of venture investment.

October 30, 2009

Senator James M. Inhofe

1. Does Google support rapid expansion of nuclear, including opening the Yucca Mountain waste facility? Does Google support drilling off the coast of CA, including near Santa Barbara?

Answer: Google does not have a position on these issues.

October 30, 2009

Senator Lamar Alexander

The Wall Street Journal reported on July 3, 2009 that California's economy will face "high risk" by 2011 due to power shortages caused by the state's renewable mandate. California estimates that raising its renewable electricity standard from 20% to 33% could cost more than $114 billion - that is more than $3,000 for each Californian. Given the electricity costs in California and reliability questions raised, is that a possible reason why Google expands its server farms outside of the state of California?

Answer: There are multiple factors that go into Google's decisions about data center location. The cost and reliability of electricity are important considerations, but not the only factors. Like other businesses, Google is keenly interested in cost-effective, reliable and safe energy supply options -- it is for this reason that we have invested in new energy technologies and support policies that will accelerate the development of better options for the future.

Senator BOXER. Thank you very much.
Mr. Foster.

STATEMENT OF DAVID FOSTER, EXECUTIVE DIRECTOR, BLUEGREEN ALLIANCE

Mr. FOSTER. Good morning, Madam Chair, members of the committee, and thank you, Senator Klobuchar, for that kind introduction.

My name is David Foster. I serve as the Executive Director of the BlueGreen Alliance, a national partnership of six major labor unions and two national environmental organizations. We bring together 8 million members from the steelworkers, the largest manufacturing union in North America, communication workers, laborers, service employees, utility workers and teachers with the Sierra Club and Natural Resources Defense Council. We touch virtually every corner of the country in our pursuit of good jobs, a clean environment and a green economy.

I am especially pleased to be given the opportunity to testify before the Environment and Public Works Committee on this critical issue, and we look forward to working with you throughout the process to pass clean, comprehensive climate change legislation that creates and retains millions of family sustaining green jobs and finances the transition to a clean energy economy.

To maximize its economic success, this package must be comprehensive. It must deal with every piece of the puzzle, capping carbon emissions, providing incentives for job creation, investing in clean energy, preventing carbon leakage, and setting mandates for energy efficiency and renewable energy production.

Some say that it would be easier to pass one piece of the puzzle and then try to move on to the next. But doing so underestimates the complexity of the problem, sends contradictory messages to our energy markets, and most importantly, fails to solve the underlying climate crisis.

Capping carbon emissions will create the necessary incentives for America to develop its clean energy economy. Without the certainty of true emissions reduction, we can achieve neither our environmental goals nor our job creation goals.

We also need to include a strong national renewable electricity standard and energy efficiency resource standard such as those introduced by the Senators Udall of Colorado and New Mexico.

The transition to a clean energy economy is the most important opportunity for strengthening and expanding American manufacturing in my lifetime. As evidenced by Gamesa in Pennsylvania, the ClipperWind facility in Cedar Rapids, Iowa, ATI Casting in LaPorte, Indiana, the Pauwels Transformers facility in Washington, Missouri, and many, many more, our workers can produce the steel, glass, precision parts and cement needed by our clean energy industries, but only if we provide them with the proper investment and protections.

We can do this by including a robust manufacturing title in the bill which would ensure that strengthening and revitalizing America's manufacturing base is a priority. There is no reason why America and its workers should not lead the world in green manufacturing.

A critical component is providing adequate allocations to energy intensive and trade exposed industries. While the Kerry-Boxer bill addresses this issue, it does not provide sufficient allowances to ensure that energy intensive industries are not put at a competitive disadvantage. This is a vital provision for preventing the leakage of jobs and carbon pollution, and I appreciate that the Chair and committee have agreed to work with us to ensure that these industries are kept whole.

In addition, the legislation should include a longer-term border adjustment provision to limit carbon leakage, ensure the fair treatment of American workers, and provide an incentive to other countries to negotiate industry sectoral agreements as those allocations phaseout. We were supportive of the House ACES bill and hope that this model can be included in Senate legislation.

I cannot emphasize enough to the committee how critical both the rebates and border measure are to the success of the climate bill. As part of the manufacturing title, climate and energy legislation should also provide incentives to help our manufacturing base convert to the clean energy economy. We appreciate the inclusion in funding of clean vehicle manufacturing provisions and hope that Senator Brown's IMPACT Act will also be included and funded.

Programs like the Retrofit for Energy and Environmental Performance and investments in improved building codes will finally put forth a dedicated effort to make buildings and homes more energy efficient. We also believe that national minimum standards are an essential part of any program receiving support from the Federal Government to spur residential energy efficiency. The State and Local Investment in Energy Efficiency and Renewable Energy, included in the bill, will provide the dedicated investment to support deployment of critical technologies and practices.

Our work force must have all the necessary tools and knowledge to successfully work in green jobs. We can do this by offering training for all who want the opportunity. We believe that the Green Jobs Act of 2007 gives us the best framework, and we thank you for providing allowances to fund this provision.

Along with training, we must open doors to certain communities that are too often left out. The Green Construction Careers Demonstration Project provides an outlet that will promote quality employment practices that are accessible to low income communities and workers.

I want to close by telling the story of the R.E. Burger power plant in Shadyside, Ohio. A coal-fired power plant originally built in the 1940s, Burger needed to be fitted with new pollution control equipment. That equipment proved to be too costly, and the owners were preparing to close the plant and lay off hundreds of workers in an already economically depressed area.

Thankfully, with the help of Utility Workers Local 350, FirstEnergy decided to retrofit the plant and convert to biomass. This proved to be more cost effective and saved the jobs of over 100 employees and the creation of another 200 jobs. The Burger plant today is poised to become one of the largest biomass-fueled plants in the country.

After comprehensive climate legislation is enacted, we will see more and more plants like Burger. Many will be retrofitted with carbon capture technology and some switched to natural gas or biomass. We will see concentrated solar power plants built where there has never been a power plant before. We will see wind farms going up alongside oil derricks. We will see buildings erected that emit zero carbon pollution and produce zero waste.

We look forward to working with you to pass what could and should be the greatest job creating bill ever passed by the U.S. Congress.

Thank you.

[The prepared statement of Mr. Foster follows:]

Testimony of David Foster
Executive Director, Blue Green Alliance
Committee on Environment and Public Works
October 28, 2009

INTRO

Good morning, Madame Chair, Members of the Committee; my name is David Foster. I serve as the Executive Director of the Blue Green Alliance, a national partnership of six major labor unions and two national environmental organizations. We bring together eight million members — touching virtually every corner of the country — in pursuit of good jobs, a clean environment and a green economy.

The Blue Green Alliance, formally launched by the United Steelworkers and the Sierra Club in 2006, has since brought together the Communications Workers of America (CWA), Natural Resources Defense Council (NRDC), Laborers' International Union of North America (LIUNA), Service Employees International Union (SEIU), Utility Workers Union of America (UWUA) and the American Federation of Teachers (AFT). This collaboration of labor unions and environmental organizations is based on our common belief that building a clean energy economy will create good jobs, reduce the carbon emissions that cause global warming and make America more energy independent.

Before serving in this capacity, I spent 31 years as a member of the United Steelworkers, and for 16 years, served on the union's International Executive Board as the Director of District 11, a 13-state region based in Minnesota.

The Blue Green Alliance, together with its labor and environmental partners, has become one of America's leading advocates for transitioning to clean energy as a strategy for confronting America's energy, climate and environmental challenges. I am especially pleased to be given the opportunity to testify before the EPW Committee on this critical issue, as I did before the House Energy and Commerce Committee a few months ago.

Earlier this year, in response to the deepening economic, energy and climate crises, the Blue Green Alliance put forth a policy statement on climate change legislation[i] — the first such joint statement of our labor and environmental partners, and for some of them, their first public statement on climate change.

Following the release of that statement, our alliance worked with members of the House of Representatives to work through particular provisions — and ultimately support — the American Clean Energy and Security Act. As a result, thousands of workers across the country wrote letters and op-eds, made phone calls and attended town hall meetings in support of the overall effort to transition to the clean energy economy. Construction workers, janitors, steelworkers, industrial union workers and utility workers came to D.C. to pound the marble halls in support of the House bill and to urge the Senate to act, all because we have a huge opportunity to transform our economy by transitioning to clean energy — to create good jobs while improving the environment for our children and grandchildren.

Thanks to the leadership of Senator Boxer and Senator Kerry, and the dedication of many other Senators both on the EPW committee and off, we've seen the introduction of the Clean Energy Jobs and American Power Act. The Blue Green Alliance looks forward to working with you throughout this process to ensure that comprehensive climate change legislation creates and retains millions of family-sustaining, green jobs and finances the transition to a clean energy economy.

The Problem and the Solution

Climate change is a creeping threat to our ecosystem and our global and domestic economies. If left unchecked, its consequences will have devastating impacts on our economy and our way of life, as confirmed by numerous reports, including the U.S. Global Change Research Program's New Assessment of National, Regional Impacts[ii] and Sir Nicholas Stern's Stern Review, prepared for the British Government.[iii]

Radical changes in temperature, weather, water quantity, and air quality have the potential to throw even the most stable economies into an upheaval. We can debate the impact of certain provisions of this legislation on certain sectors of our economy, but our failure to act would saddle future generations of Americans with the consequences of unfettered climate change that would unquestionably bear heavily on our economic security. Perhaps more importantly, the failure to act would also be a tragic missed opportunity to solve the current unemployment crisis in America with a new generation of good jobs and vault America into the lead in the global clean energy economy.

Ignoring climate change is also a vote for the status quo — a status quo that is unsustainable. The current economic model drove oil prices to more than $140 a barrel in 2008, contributed to skyrocketing food prices and global food shortages, and resulted in massive trade imbalances. That status quo helped whittle away good, family-sustaining American jobs for years.

Passing comprehensive climate change and energy legislation puts us on a new path, one where there is greater hope for job creation and a cleaner environment. A recent report by the Political Economy Research Institute at the University of Massachusetts-Amherst[iv] showed that a $150 billion investment in clean energy will create 1.7 million jobs across the United States. .

Another recent University of California Berkeley report confirms[v] the job-creating potential of comprehensive climate change and clean energy legislation. This study shows that comprehensive clean energy and climate change legislation could create 1.9 million jobs, increase annual household income by $1,175, and boost GDP by up to $111 billion.

To maximize its economic success, this package must be comprehensive. It must deal with every piece of the puzzle: capping carbon emissions, providing incentives for job creation, investing in renewables and energy efficiency, accounting for carbon leakage and setting mandates for energy efficiency and renewable energy production. Some say that it would be easier to pass one piece of this puzzle and then try to move on to the next. But doing so underestimates the complexity of this problem, sends contradictory messages to our energy markets and, most importantly, fails to solve the underlying climate crisis.

SPECIFIC PROVISIONS

Capping carbon emissions will create the necessary incentives for America to develop its clean energy economy. The Blue Green Alliance is pleased to see the Committee take thoughtful and significant action in its target on the capping of emissions. Without the certainty of true emissions reduction, we can achieve neither our environmental goals, nor our job creation goals.

We also need a strong, national Renewable Electricity Standard (RES) and Energy Efficiency Resource Standard (EERS) that will drive the expansion of the American clean energy economy and make the U.S.

a leader in the increasingly competitive global clean energy industry. When the Clean Energy Jobs and American Power Act is taken to the Senate floor and combined with legislation from other Committees, the Blue Green Alliance urges Senators to include the RES bill introduced by Senator Udall of Colorado and Senator Udall of New Mexico in the final package that is voted on by the Senate.

A study released earlier this year[vi] by the Blue Green Alliance and the Renewable Energy Policy Project found that if the U.S. passed a national Renewable Electricity Standard of 25 percent by 2025, and if all the renewable energy components were made in the U.S., more than 850,000 manufacturing jobs could be created across all 50 states by U.S. firms that already exist today. Economic models show that a federal RES at 25 percent by 2025 would generate over 39,000 jobs in Indiana; 42,000 in Pennsylvania; 34,000 in Michigan; 51,000 in Ohio; and 35,000 in Wisconsin.

A strong cap combined with an RES and EERS will reduce emissions in the most cost effective way while providing the foundation upon which to build America's clean energy economy. These policies already have a history of creating jobs in America. My home state of Minnesota currently has a 25 percent RES, and is home to Mortenson Construction, one of the nation's leading construction companies specializing in wind-farm installation.

Following the passage of a state RES in Pennsylvania, Gamesa — a Spanish wind turbine company — opened one of several new blade, turbine and tower factories at the site of a shut down steel plant, bringing more than 1,000 jobs to the state and putting laid off steelworkers back to work in Ebensburg, Pennsylvania.

I want to tell you about a few workers that have directly seen the benefits of a new green economy. Phil Taylor is a tool-and-die maker for a Peerless-Winsmith in Springville, New York, where he has worked for 40 years, and for most of the last 20, has served as the IUE-CWA local president. He helps to make speed-reducers, or gear boxes for a variety of products. Right now, they make units for solar fields. Solar panels need to turn to follow the sun, and this company makes gear boxes that rotate the panels to follow the sun's trajectory.

Lee Geisse is a greaser at an Allegheny Ludlum plant in Louisville, Ohio, where she helps in the production of specialty steel that is used to build the hub for windmills. Lee has worked at her plant for 23 years and is a member of the United Steelworkers union.

There are many stories like this across the country, and we will have more with the passage of a comprehensive climate change and clean energy bill.

The transition to a clean energy economy is a tremendous opportunity for strengthening and expanding American manufacturing. As evidenced by the Gamesa example, and others, including the ClipperWind facility in Cedar Rapids, Iowa, ATI Casting in LaPorte, Indiana, and the Pauwels Transformers facility in Washington, Missouri, our workers can produce the steel, glass, precision parts and cement needed by the clean technology industry, but only if we provide the proper investment and protections.

Our domestic climate legislation can prevent carbon leakage and assure international competitiveness. We can cut global warming pollution from all important sectors while making sure that the production of steel, aluminum, cement and other energy-intensive and trade-sensitive commodities which are necessary to build our clean energy infrastructure stays in the U.S., and is not shifted to other countries without adequate global warming policies. We can do this with a robust manufacturing title in the bill, which would ensure that strengthening and revitalizing America's manufacturing base is a priority. There is no reason why America and its workers should not lead the world in green manufacturing.

A critical component to achieving this goal is the allocations to energy-intensive and trade-exposed industries. While the Kerry-Boxer bill allocates allowance value to these industries, unfortunately, it does not provide a sufficient portion to ensure that energy-intensive industries receive the assistance needed to keep them from being put at a competitive disadvantage. This is a vital provision for preventing leakage of jobs and carbon pollution. With sufficient allocations, these industries will have adequate time to transition to cleaner, more efficient methods. I appreciate that the Chair and Committee have agreed to work with us to ensure that these industries are kept whole. It is critical that we fix this shortfall.

In addition to sufficient allocations for energy-intensive industries, it will be necessary for this legislation to include a longer-term border adjustment provision to limit carbon leakage and ensure the fair treatment of American workers if countries fail to address global climate change as those allocations phase out. The Blue Green Alliance has been working with the Senate Finance Committee and have made clear to the Committee the importance of getting the border measure right. We were supportive of the end result of the House ACES bill, and hope that we can be at the same place at the end of the Senate process. I cannot emphasize enough to the Committee how critical both the rebates and border measure are to the success of the climate bill and to the support of the Blue Green Alliance and many labor unions.

As you are well aware, a ton of steel manufactured in the U.S. results in one ton of carbon emissions. A ton of steel manufactured in China results in 2.5 tons of emissions. It would be a tragedy for both workers and the environment if our solution to global warming resulted in closing U.S. steel mills and importing needed steel products from China.[vii] This bill can avoid that result as long as it puts in place the appropriate rebates to energy-intensive industries and a border-adjustment mechanism like the one included in the House ACES bill.

As part of a manufacturing title, climate and energy legislation should also provide incentives to help our manufacturing base convert to the clean energy economy. We appreciate the inclusion and funding of clean vehicle manufacturing provisions, and hope that provisions like Sen. Brown's IMPACT Act — which creates a revolving loan program in states to provide financing to small- and medium-manufacturers to fund clean energy manufacturing projects — will also be included and funded in the final product to rebuild American manufacturing into the clean, efficient industry it can and should be.

Energy saved is just as important as energy produced. It saves people and businesses money, reduces our reliance on fossil fuels and creates jobs. Increased investments in energy efficiency would create more opportunities for high-road construction jobs and make our transition to a clean energy economy smoother and more expeditious. Buildings in the United States consume more energy and generate more carbon emissions than any other sector of the economy. Reducing this energy consumption should be a priority.[viii] From retrofitting factories, schools, and buildings to weatherizing homes and apartment buildings, and ensuring that they are operated and maintained to stay green, our country's workers can implement energy efficiency improvements immediately.

Such an effort can help reinvigorate the construction industry, which has seen the loss of 1.5 million jobs since this recession began in December 2007.[ix] With this grim news, we need investments in both commercial and residential construction.

Programs like the Retrofit for Energy and Environmental Performance (REEP) program and investments in improved building codes, will finally put forth a dedicated effort to make buildings and homes more efficient. REEP can be even further improved by requiring quality Operations and Management programs to be established after buildings have been retrofitted. With these investments, we can begin to retrofit America's buildings and weatherize America's homes to make them as energy efficient as European buildings, where energy consumption is half the per capita rate of our country. Such energy savings can be put to use to finance a high-wage, high-road weatherization industry where livable wages are paid, health care is provided, and essential career- and job-training opportunities are made available to communities across America.

In the past year, LIUNA has made the residential energy efficiency industry a national priority. They have an expert weatherization curriculum and the training instructor pool necessary to deliver the numbers of well-trained and well-paid workers to perform quality retrofits across the country. They have exciting programs underway in New Jersey, Delaware, Nevada, Chicago, and Ohio. The demand for weatherization work will require an industry that can train and connect workers to hundreds of thousands of new jobs. In 2009, LIUNA Local 55, working with the Garden State Alliance for a New Economy, provided weatherization training for unemployed local residents in Newark.

It is essential to protect the underlying value of our homes and buildings by establishing high-quality standards for retrofit and weatherization work. To this end, we believe that national minimum standards are an essential part of any program receiving support from the federal government that is designed to spur residential energy efficiency, and we look forward to working with the Senate to ensure that such standards are included in the final bill.

The Building Service Local 32BJ of SEIU in New York has been greening the city's buildings for the last four years. Their training fund, which is a joint labor-management organization, is now poised to significantly expand upon its existing green training experience by training 1000 green superintendents in one year to help make the city greener. What will help encourage and expand this effort is policy in the legislation requiring quality operations and management programs. After all, the maintenance and operations of green buildings are just as critical to our efforts to combat climate change as the actual initial greening and retrofitting of buildings. And it also means additional green jobs.

The State and Local Investment in Energy Efficiency and Renewable Energy will provide the dedicated investment in energy efficiency and renewable energy to support and accelerate the implementation and deployment of these technologies and practices. Directing these funds to reequipping manufacturing facilities, deploying clean energy technologies and the facilities and equipment that produces them, improvements in transmission, smart grid development, and advances and deployment of energy efficiency will be one of the important drivers to create good, green jobs.

The Blue Green Alliance also supports the inclusion of the State Recycling Programs, and hopes to work with the Committee to fund it. This program will create numerous jobs reducing waste and reusing materials that would otherwise be left to sit in toxic landfills emitting methane — by far the most potent greenhouse gas. It will transform our current waste infrastructure and assist the U.S. in meeting its energy and climate goals while creating jobs. This program can create tens of thousands of new jobs and should include measures that will ensure taxpayers that the funds will create good, family-sustaining jobs.

Our workforce must have all the necessary tools and knowledge to successfully work in green jobs. We can do this by offering training for all who want the opportunity. We believe that the Green Jobs Act of 2007 gives us the best framework for training and implementation of these jobs in a fair and equitable manner. We thank you for providing allowances to fund this provision. In addition, we urge you to maintain the integrity of the provision by ensuring that labor-management partnerships continue to be a mandatory part of the training process.

Along with training, we must open doors to certain communities who are too often left out. The Green Construction Careers Demonstration Project provides an outlet that will promote quality employment practices that are accessible to low-income communities and workers. We appreciate the funding of this demonstration project, and believe it will go a long way to ensuring that these communities are an integral part of the transition to the clean energy economy.

While many jobs will be created in areas related to renewable energy and energy efficiency, some jobs in other areas will potentially be lost and communities strained. It is critical that the final legislation builds on the inclusion of the Climate Change Worker Adjustment Assistance Program to include a robust and comprehensive program to provide assistance to workers who are adversely affected by the changes in policy. Workers should not only receive a readjustment allowance and health care, but also access to employment training.

We cannot focus solely on the workers of today. In order to be prepared, we need to ensure that workers of the future have the requisite skills and knowledge base. The Clean Energy Curriculum Development Grants give the Secretary of Education the ability to fund programs that prepare students for careers in the new economy. This is a great start, but we should look for more ways to invest in our citizens and workers of tomorrow.

Schools across the country are beginning to incorporate a greener education curriculum. For example, in Connecticut, some teachers within AFT are partnering with businesses and community organizations to obtain green teaching tools, such as a wind turbine donated by the local power company, a cutaway model of a turbine inside the school's electrical shop that's fully functional for teaching, and a demonstration greenhouse built by tenth grade students to model solar panels and small LED lights. The students install meters that monitor electricity production from the wind turbine that is provided to the school. AFT and teachers across the country understand that the new economy is the green economy and we can't start to train too early.

The Clean Energy Jobs and American Power Act has shown significant commitment to ensuring that American workers are treated fairly and that good, long-lasting jobs are created in the clean energy economy. We appreciate the inclusion of prevailing-wage provisions, requiring that all federally-funded construction jobs be subject to prevailing wages. We also ask that you expand opportunities to provide quality jobs in the clean energy economy for all Americans. All new jobs funded in part or in whole by the federal government should pay fair wages and benefits, and contractors should pay a living wage and abide by responsible contracting principles.

As we transition to the clean energy economy, it is important that we effectively deploy our varied portfolio of energies and technology. Carbon capture and sequestration (CCS) technology and its deployment can allow us to use coal in a cleaner and more efficient way while creating high-skilled, high-wage jobs for American workers. We are pleased with the direction of the ongoing discussions on the CCS language that is in the legislation and believe that funding should be provided to CCS research, development and deployment. Particular attention should be paid to the technologies that will apply to capturing carbon from existing facilities and that will apply to the steel and cement industries as well as power generation.

CONCLUSION

Climate change is a global problem that requires a global solution. Without passing comprehensive climate legislation that guides the transition to clean energy in the United States, we will not achieve this global solution.

This is our chance to lead.

We appreciate that the Kerry-Boxer bill includes funding to develop markets for American clean energy technologies in developing countries that take part in the global effort to reduce emissions, funding for developing countries to adapt to climate change, and funding to achieve additional emissions reductions by combating deforestation.

These provisions are essential to secure a global climate treaty.

For the United States, this is an opportunity to rebuild our economy and protect our environment for future generations of Americans.

This is an opportunity to remake a stagnant economy and invest in our country's middle class, which was the backbone of prosperity in the 20th century.

This is our opportunity to ensure that the educators, manufacturers, construction and maintenance workers who gave our country its competitive advantage in the 20th century are at the forefront of building a clean energy economy in the 21st.

With legislation like Kerry-Boxer, we will see more examples like the R.E. Burger power plant in Shadyside, Ohio. A coal-fired power plant originally built in the 1940s, Burger needed to be fitted with pollution control equipment to meet necessary standards for coal plants. The equipment proved to be too costly and the owners were moving to close the plant and lay off hundreds of workers in an already economically depressed area. Thankfully, with the help of UWUA Local 350, FirstEnergy decided to retrofit the plant and convert to biomass. This proved to be more cost effective and saved the jobs of over 100 employees on site, and will pave the way for the creation of another 200 jobs. The Burger plant is poised to become one of the largest biomass-fueled plants in the country.

After comprehensive climate legislation is enacted, we will see more and more plants like Burger. Many will be retrofitted with CCS technology and some switched to natural gas. We'll see concentrated solar power plants built where there's never been a power plant before. We'll see wind farms go up alongside oil derricks. We'll see buildings erected that emit zero carbon pollution and produce zero waste.

Most importantly, we'll see American workers building, producing, training and maintaining all of these projects.

We look forward to working with you to pass what could and should be the greatest job-creating bill ever passed by the U.S. Congress. This is a rare opportunity to confront our nation's challenges — energy, economy and climate — and begin to tackle them simultaneously.

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BLUEGREEN ALLIANCE

October 30, 2009

The Honorable Barbara Boxer
The Committee on Environment and Public Works
United States Senate
410 Dirksen Senate Office Building
Washington, DC 20510-6175

Dear Madame Chair:

Thank you for providing me the opportunity to testify before your committee on Wednesday, October 28. Below, please see my responses to the follow-up questions asked by yourself and Senators Sanders, and Klobuchar.

Senator Barbara Boxer

1. *Mr. Foster, are there additional issues that are relevant from your testimony that you would like to elaborate on for the record?*

I would like to expand on my comments regarding the importance of the international competitive piece of the bill. Some might argue that border-adjustment provisions are protectionist and will spark trade disputes that would be more harmful to the global economy than the problems they are designed to correct. In fact, the inclusion of the border-adjustment provisions are designed to incent a negotiated solution to the competitiveness problems created by pricing carbon differently in different countries at the onset of a global treaty. In the House ACES bill, a negotiating process was created to encourage countries to reach sectoral agreements in each energy-intensive industry before the onset of the border-adjustments. These sectoral agreements could be negotiated separately in each energy-intensive industry and would govern the relevant factors designed to reduce green house gas emissions, thereby eliminating the need for border-adjustments while cleaning up the environment.

The three-pronged approach—adequate allowances in the early years to compensate for transition costs, incentives to negotiate sectoral agreements in the mid-term, and border adjustments in the event of the failure of negotiations—provides the U.S. with the opportunity to move forward on implementing climate change solutions immediately. It also gives the international community a clear signal of our willingness to minimize the trade implications of climate change to specific energy-intensive sectors of the economy and resolve those issues individually through negotiations, while giving American workers an equally clear signal that their jobs will not be sacrificed in what could otherwise become a futile attempt to decrease emissions.

These provisions are not protectionist. They represent sound environmental and economic policy and, if adopted by the Senate, will give the global community a road map on how to achieve a global agreement that is good for the environment and good for economic growth while making it clear that the U.S. will not swap regulated pollution at home for unregulated pollution abroad.

We also appreciate that the Kerry-Boxer bill includes funding to develop markets for American clean energy technologies in developing countries that take part in the global effort to reduce emissions, funding for developing countries to adapt to climate change, and funding to achieve additional emissions reductions by combating deforestation.

These provisions are essential to secure a global climate treaty. But they are also good for American job creation. Take the issue of deforestation, for instance. Today there is a direction connection between the loss of jobs in the paper industry in the US and tropical deforestation. Deforestation currently contributes about 30% of global greenhouse gases each year. In many countries much of that deforestation is illegal. The United Nations Environment Program estimates, for instance, that 80% of timber harvesting in Indonesia takes place in contravention of that country's own laws. It's like clear cutting Yellowstone National Park and not even paying the government for that right. In 2007, the United Steelworkers, the Sierra Club and New Page Paper Company filed the first illegal logging trade case with the US Department of Commerce. In that case we asked for tariffs against the coated free-sheet paper products of Asia Pulp and Paper, one of the largest paper conglomerates in the world, for the unfair advantage it gained in world paper markets by using pulp from illegally logged timber in Indonesia in its products.

Another trade case is currently underway initiated by several U.S. paper producers, demonstrating again the direct connection between global warming and the loss of employment by thousands of pulp and paper workers in the U.S. Interestingly, the loss of employment is equally stark in Indonesia where the rise in illegal logging has caused massive job loss to Indonesian forestry workers. Kahutindo, the union of Indonesian forestry workers, reports the loss of over 100,000 jobs in that industry in the last decade. Again, if we pass climate legislation in the U.S. and start recognizing the real value of those tropical rainforests as carbon sinks, we'll solve climate change and reinvigorate our domestic pulp and paper industry.

Senator Bernard Sanders

1. *We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?*

Along with our environmental partners, the Laborer's International Union of North America and the Service Employees International Union strongly support setting cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric local distribution companies.

As shown by reports by the American Council for an Energy Efficient Economy, significant investments in and strong policies for energy efficiency saves people money, creates jobs, and offers the best and most immediate method to addressing climate change.

Senator Amy Klobuchar

1. *In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy – from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?*

Simply put, there are two pieces that will go a long ways toward achieving this certainty. First, we must establish a strong national renewable electricity standard (RES), much like S.433 or your S. 826. As you state, Minnesota is a great example of how this will work, as our home state has a 25% target of renewable energy production by 2025. After implementation of this policy, the private sector successfully took off to meet these achievable targets. To get the same success nationally, we need a similar policy.

The second piece is a proper price on carbon, which Kerry-Boxer achieves. By placing a cap on carbon emissions and establishing a regulated market, we will ensure that emitting carbon costs a fair, market-based price. Adding this cost into the equation will provide the private sector the signal that certain production processes must be changed. With this signal, the private sector will begin to heavily invest in cleaner technologies, moving our country to the clean energy economy.

With these national policies, along with dedicated investments and proper worker protections, we should expect a budding, domestic clean energy industry to forcefully take hold of our economy.

2. *Mr. Foster, as you know, our home state, like many others represented on this Committee, has been hit hard by the shift of basic manufacturing from factories here in the United States to factories overseas. How does this legislation spur the creation of new jobs in manufacturing and industry within the United States?*

By putting a price on carbon and investing in the production and deployment of clean energy technologies, Kerry-Boxer establishes a solid framework for which manufacturing can be a big part of our clean energy future. With that said, the framework is currently incomplete. Comprehensive climate change legislation should have a separate and robust manufacturing title that includes investments, safeguards, and policies that spur new manufacturing and improvements in existing manufacturing.

In particular we need to first shore up the rebate account for energy-intensive, trade-exposed (EITE) industries. Kerry-Boxer, as currently written, does not provide a sufficient amount of allowances to these manufacturing-heavy industries. Without these allowances, we cannot start to consider the reinvigoration of manufacturing.

Once we solve the EITE shortfall, we must then include more investments directly for manufacturing. Building on the investments in renewable energy deployment and technology development, we must provide an influx of funding for the reequipping of manufacturing facilities to build the components of the clean energy economy. Kerry-Boxer begins to address this issue by including funding for clean vehicle manufacturing and allowing for state funds to go to reequipping manufacturing facilities, but to truly spark the manufacturing industry we must implement and fully fund policies like Sen. Brown's IMPACT Act.

Finally, we must ensure that our manufacturing sector is not subject to carbon leakage. Currently, Kerry-Boxer includes a Sense of the Senate stating that a border adjustment measure will be included in the bill. We appreciate this and have been working with the Finance Committee to ensure the border measure is included and properly crafted.

Sincerely,

David Foster, Executive Director
Blue Green Alliance

Senator BOXER. Thank you very much, Mr. Foster.

It is our pleasure to welcome Mayor Michael Nutter, the Mayor of Philadelphia, Pennsylvania.

STATEMENT OF HON. MICHAEL A. NUTTER, MAYOR OF PHILADELPHIA, PENNSYLVANIA; TRUSTEE, U.S. CONFERENCE OF MAYORS

Mr. NUTTER. Madam Chairman Boxer, Ranking Member Inhofe and members of this committee, I want to thank you for the opportunity to testify on the Clean Energy Jobs and American Power Act.

I also want to thank my Senator, Senator Arlen Specter, for the wonderful introduction, very complimentary, and I appreciate that. The Senator and I have a long-standing working relationship on behalf of Philadelphia and some Pennsylvanians for a long period of time.

My name is Michael A. Nutter, Mayor of the city of Philadelphia and a Trustee of the United States Conference of Mayors. I am pleased to be here today on behalf of the Conference in full support of this legislation, and I would ask, Madam Chairwoman, that my full testimony be submitted for the record.

Senator BOXER. Without objection.

Mr. NUTTER. Thank you.

The United States Conference of Mayors has been urging Congress to pass a comprehensive climate protection plan that reduces our Nation's greenhouse gas emissions, encourages renewable energy, increases energy efficiency and enhances our economic security. The bill before us today will achieve these outcomes.

As all of you know well, our Nation finds itself at a difficult time. Faltering city, State, Federal and global economies, rising national security challenges further complicated by rising environmental threats, now define the first decade of this new century. We must confront these challenges with courage, vision and action.

And that is exactly what this committee is doing today in moving forward with this important legislation. If we do this right, we will chart a new direction that will increase our energy independence, reinvigorate our economy and create new jobs in the process.

I would like to discuss how this legislation will not only protect our environment, but will also support economic recovery and longer-term economic growth.

On behalf of the Nation's mayors, I want to thank you, Chairwoman Boxer, Ranking Member Inhofe and the members of this committee for recognizing the important role that city and local governments must play in a comprehensive climate protection plan by including commitments to the Energy Efficiency and Conservation Block Grants Program, also known as EECBG.

Cities in our metro areas are not only the economic engines of the United States economy, but they also represent some of the biggest users of total energy consumed. Local governments are responsible for transportation networks, water and wastewater systems, building code enforcement, fleets of vehicles, solid waste disposal and recycling collection. These activities are a source of many of our emissions. But cities are also a source of innovative solutions that will have a significant impact on reducing greenhouse gas emissions and energy consumption while also creating new jobs.

Under ARA, the city of Philadelphia will receive $14.1 million in EECBG funding. We have developed a plan that makes immediate investments in energy efficiency and conservation while leveraging and extending these investments into the future, generating jobs and economic benefits that will be realized over the coming months and years ahead.

In 1997, our Streets Department replaced all of our red light traffic signals with LEDs, saving $8.4 million and over 40 million tons of greenhouse gas emissions over 10 years. Using EECBG money and other leveraged funds, we will convert an additional 58,000 yellow and green traffic signals and replace 27,000 red LED lights. The project will save our city $1 million in electric costs every year.

There are enormous potential returns to energy saving investments in building retrofits. The debt incurred to fund the improvements will quickly be offset by reduced energy operating costs. With EECBG and other leveraged funds, again we will be offering low interest loans to commercial, industrial and institutional property owners that wish to undertake building energy efficiency retrofit projects. In addition, $500,000 in matching grants for building energy efficiency improvements will be made available to small businesses.

Besides the EECBG, there are numerous other programs contained in this legislation that are good for both the economic and job creation fronts. I wanted to highlight a few that are going on in Philadelphia and what this legislation can do for us in the future.

In 2008, we installed a new solar hot water system on a riverside correctional facility, the first in the Nation. The additional cost of a solar heating system is expected to pay for itself through lower energy costs in less than 9 years. Over its useful life, estimated at 25 years, the solar system will save over $1 million and reduce emissions by over 1 million pounds of CO_2.

There is potential to develop and deploy solar at scale. We have acres and acres of public rooftops, also knowing as housing in Philadelphia, row homes in our city that could support similar installations. The city of Philadelphia currently spends $19 million annually on housing preservation and weatherization, supporting about 3,600 projects a year. An expanding building and retrofit program contained in this bill could become part of a pipeline to retool Philadelphia's work force to meet a growing demand in the private market for building retrofit.

A new job training program developed by our Energy Coordinating Agency will certify new weatherization specialists. Some of this training can be completed in as little as 2 weeks, allowing unemployed and underemployed Philadelphians to transition rapidly into a sector with tremendous opportunity. The total number of trainees is expected to be over 800 in the first 2 years of operation.

Our Nation cannot remain economically competitive if we continue down a path where petroleum is our primary source of power for the transportation sector. This means that all federally assisted transportation investments must—and this legislation does—emphasize sustainable transportation.

Philadelphia has already decreased its transportation greenhouse emissions by nearly 10 percent from its 1990 levels. But we have established a further goal of reducing emissions by 10 percent by 2015. My experience in Philadelphia is characteristic of so many cities that are moving forward with these kinds of investments.

Let me conclude by saying that I have provided a few examples of the energy and climate work underway in our city, and I am just one example of what many mayors across America are doing in our Nation. These innovative practices and programs stimulate the economy, create jobs and protect our environment. At the same time, we know that the potential to do more exists, including creating millions of new jobs in advanced and growing opportunity through this work and we have only scratched the surface.

I congratulate you, Chairman Boxer, Senator Kerry and members of the committee for your hard work on this critically important legislation. The Nation's mayors support your efforts, and we encourage the Senate to move quickly to enact comprehensive energy and climate legislation during this Congress.

Thank you, Madam Chairwoman.

[The prepared statement of Mr. Nutter follows:]

Testimony of the Honorable Michael A. Nutter
Mayor of Philadelphia and Trustee of The U.S. Conference of Mayors

Hearing on S. 1733, The Clean Energy Jobs and American Power Act
Before the Senate Environment and Public Works Committee

October 28, 2009

Chairman and Members of the Committee, I thank you for this opportunity to testify on this important piece of legislation, S. 1733, The Clean Energy Jobs and American Power Act. My name is Michael A. Nutter, Mayor of Philadelphia and I serve as a Trustee for The U.S. Conference of Mayors.

I'm pleased to be here on behalf of the Conference of Mayors to convey the nation's mayors' support for this much-needed legislation. Since 2005, the Conference of Mayors has been urging Congress to pass a comprehensive climate protection plan, one that reduces our nation's greenhouse gas emissions through an emissions trading system, adapts to anticipated climate threats, transitions to greater use of renewable energy and cleaner energy supplies, increases commitments to energy conservation and efficiency, and enhances our economic security through the accelerated development of homegrown energy supplies and technologies. The bill before you today will achieve these outcomes.

The U.S. Conference of Mayors is a national, non-partisan organization that represents cities with populations of over 30,000 or more, through its chief elected official, the Mayor. The Conference of Mayors was formed back in 1932 as a response to the Great Depression. At that time, mayors gathered to speak with one voice to promote policies and programs that would move our country in a direction that would promote jobs and economic competitiveness. We find ourselves similarly challenged today. Faltering national and global economies and rising national security challenges, further complicated by rising environmental threats, now define the first decade of this new century.

We must confront these challenges with courage, vision and action, as I believe this Committee is doing today in moving forward with this important legislation. If we do this right, we will chart a new direction that increases our energy independence, reinvigorates our economy, and creates more new jobs in the process.

With this said, I look forward to enactment of comprehensive energy and climate legislation that includes as its centerpiece, the Clean Energy Jobs and American Power Act. In my testimony, I will share some perspectives on current economic conditions, the potential for creating green jobs, and how this legislation can support economic recovery and longer-term economic growth into the future.

Status of U.S. Economy/Metro Areas

The Conference of Mayors has worked extensively on the role of metropolitan economies in shaping U.S. economic growth. These 363 city/county metro economies are home to 86 percent of the U.S. employment, more than 90 percent of wage income and nearly 90 percent of our gross domestic product. Most notably, our work with IHS Global Insight indicates that an estimated 94 percent of all U.S. economic growth over the next twenty years will occur in these 363 areas.

Our recent analysis shows that these areas – in larger numbers than ever before – are now struggling to sustain their economic output and generate jobs for people who need them. As this data shows, the nation's economy will not recover until these economic engines of the U.S. economy are revived.

Importantly, this reality underscores the importance of the Committee's decision to invest directly in the cities and counties that comprise these economies by including commitments to the Energy Efficiency and Conservation Block Grant Program in the legislation before you.

Green Jobs Report

This Committee is familiar with the Conference's work on green jobs and the potential employment benefits of a shift to a greener economy. Specifically, the Conference of Mayors earlier this year provided information on IHS Global Insight's analysis, *U.S. Metro Economies – Current and Potential Green Jobs in the U.S. Economy*, for the Committee's record.

Again, I would like to share some brief comments on this analysis, based on scenarios calling for increased energy efficiency in new and existing buildings; greater reliance on ethanol and biodiesel fuels in the transportation sector, and securing a much larger share of our electricity from renewable energy supplies. To achieve these forecasted jobs, these scenarios assumed private and public sector changes, including laws, policies and practices at the federal, state and local levels would be sustained and, in instances, enhanced. Among the report's key findings:

- There will be 4.2 million green jobs in the U.S. economy by 2038 if we achieve the goals of the scenarios, five times larger than the 2006 baseline of slightly more than 750,000 jobs nationwide.
- Green jobs will represent 10 percent of all new jobs by 2038, and will be the single largest source of new jobs in the economy.
- Where a metro area starts today, in terms of its current share of existing green jobs, is not necessarily where its economy will end up in thirty years, meaning that all local areas (metropolitan and non-metropolitan areas) will have the opportunity to increase their relative share of the green economy.

The report also provided first ever estimates, on a metro-by-metro basis, of the current green jobs in these 363 areas, which we are calling our metro green jobs index. Going forward, as we further refine existing data and develop new data and measures, local leaders will be able to track how their areas are doing in developing and attracting green jobs, showing policy-makers and the public the quantifiable economic and employment benefits of a greener economy. Over time, this will give us tools to measure the effects of our policies and investments. And, it will challenge those directly who assert that green jobs is simply a goal or vision, not a justifiable economic strategy.

We do believe that our analysis was somewhat conservative because it does not provide a comprehensive assessment of the potential for green jobs in the U.S. economy. For example, our scenario for green jobs in the transportation sector was largely based on switching to alternative fuels in vehicles, leaving out the many green jobs that will result if we reengineer our transportation infrastructure systems to make them less carbon dependent. The nation's mayors support your efforts to place more emphasis on reducing greenhouse gas emissions in the transportation sector

With these points as context, I would like to call attention to some of the key provisions of interests to the nation's mayors, noting how we believe this legislation improves the environment and creates jobs.

Energy Efficiency and Conservation Block Grant (Title II, Section 202)

Cities and their metro areas are not only economic engines of the U.S. economy and where jobs must be created for our future, but these population centers represent some of the biggest users of total energy consumed, and, as such, the biggest producers of greenhouse gas emissions. At the city and metro level, we have the potential of implementing solutions that, due to our economy of scale and other factors, will have the most significant impact on reducing greenhouse gas emissions and energy consumption while also creating new jobs.

This explains why the nation's mayors have so strongly advocated for the inclusion of the Energy Efficiency and Conservation Block Grants Program (EECBG) in a comprehensive energy and climate change bill. On behalf of the nation's mayors, I want to thank you Chairman Boxer and the members of this Committee for recognizing the important and necessary role that cities and other local governments must play in a comprehensive, national energy and climate protection plan by including the EECBG Program in your proposed legislation.

Long-term, sustainable funding for the EECBG Program is a top priority for The U.S. Conference of Mayors and the other local government organizations, including the National League of Cities and the National Association of Counties. Funded for the first time through the Recovery Act, this program is administering $3.2 billion directly to state and local governments to support energy efficiency, conservation and renewable energy technologies. This infusion of funding is supporting both practical and innovative projects across the country, helping local communities to make strategic investments while positioning the country for shifts in the energy economy. With the inclusion of the EECBG Program in this bill, our nation's metropolitan areas as well as smaller cities and counties will have access to additional resources to implement both short-term solutions and long-range strategies to ensure more efficient energy use, develop renewable and other homegrown energy supplies and curb overall greenhouse gas emissions.

The City of Philadelphia will receive $14.1M in formula allocation Recovery funds through the EECBG Program. We have developed an eleven-part plan that will allow us to make immediate investments in energy efficiency and conservation while leveraging and extending these investments into the future. Cities that can grow while lowering their energy consumption have an enormous competitive advantage by reducing their energy costs and developing innovative new technologies. As such, increasing energy efficiency and cultivating renewable energy sources in Philadelphia is the centerpiece of our sustainability strategy. The EECBG program provides critical funding to help us increase our energy management capacity, lower our energy use and costs, and support long-term citywide community development.

I want to give you a few examples of what Philadelphia will be able to accomplish with our current EECBG funding to demonstrate the economic and job creating benefits that will be realized over the coming 12-18 months, and hopefully beyond the Recovery and well into the future with a sustainable EECBG funding pool as is wisely provided for in this bill.

LED Lighting - In 1997, Philadelphia became the first major U.S. city to widely deploy LED (light emitting diode) in our traffic lights. Our Streets Department replaced all of our red traffic signals - red being the only color available at the time - saving $8.4 million between FY 1998 and FY 2008. In addition, we avoided over 8 million kilowatt hours (kWh) of electricity use every year and over 4 million tons of green house gas (GHG) emissions every year. With $3.05 million in EECBG money and $3.05 million in other leveraged funds, we will convert an additional 58,000 yellow and green traffic signals and replace 27,000 red LED lights. The project will save the City $1 million in electric costs each year as well as maintain or increase jobs in the LED manufacturing industry.

Greenworks Loan Program – There are enormous potential returns to energy-saving investments in building retrofits: the debt incurred to fund the improvements is quickly offset by reduced energy operating costs. But the challenge is in designing the program instruments capable of achieving these savings in the real world of homeowners and other property managers. Building retrofits may be self-financing but they are not self-implementing.

With $4.775 million in EECBG funds and $4.5 million in leveraged funds, we will be offering low interest loans to commercial, industrial, and institutional property owners that wish to undertake building energy efficient retrofit projects. There are currently few financing options available to help individual building owners with such efforts. The initiative will provide businesses with affordable capital (targeted net interest rate < 5%) to incent them to make energy efficient improvements that will help them improve their bottom line and continue to provide jobs and economic activity in the City. These low interest loans will be targeted to help businesses and non-profits that are trying to expand or are attempting to maintain a facility that would otherwise be at risk of closure. The program is intended to have dual positive impacts on businesses throughout the City – helping them reduce energy use and greenhouse gas emissions while simultaneously reducing their overall operating costs and helping them maintain jobs and economic activity. Applications will be approved based on energy savings and job creation potential.

In addition, $500,000 in matching grants for building energy efficiency improvements to small businesses that cannot afford to participate in the larger loan program. As with the loan program, organizations will apply for the grants and will be approved based on energy savings and job creation potential, and will be able to use awards to seal their buildings, purchase energy efficiency equipment, or replace old, wasteful heating, cooling, and lighting systems.

Greenworks Technology Commercialization Grant Pilot Program: A third financial incentive program Philadelphia is funding through EECBG is our innovative technology commercialization pilot. If we are to think big about green jobs up and down the income spectrum, about green jobs that can truly transform an economy, then we have to think bigger than insulation and windows. We have to think about the next generation of energy efficiency technology. That's why we're taking a small portion of our grant and using it to help local businesses develop and bring to market new energy efficiency technologies that have the potential to transform markets. At the same time, we're also aware that this kind of investment from a city government is uncommon, so we're starting small with a true pilot mentality, hoping to learn lessons about how to make smart injections of capital that can become a model for other local governments in our region and beyond.

Incentive-Based Recycling Program: The City of Philadelphia provides single stream weekly curbside collection of recyclables. In FY2009 the City achieved a 12.7% residential diversion rate. Our goal is to reach a 20% residential diversion by 2011. This increase will contribute to energy savings, reduce landfill costs and preserve the natural environment. To achieve this ambitious goal the City of Philadelphia will partner with RecycleBank to implement an incentive based recycling program. The program will be offered and made available citywide. Households that register will be rewarded for their recycling and trash reduction efforts. RecycleBank Points will be distributed to Philadelphia RecycleBank Program Members based on the average recycling rate and average trash reduction rate for participating households in each neighborhood. Residents will have the flexibility to choose the rewards they want, including the option to make donations to Philadelphia schools or other charitable causes – pumping money into the local economy. Participation will be tracked using a radio frequency identification (RFID) tag affixed on one of the household's recycling containers. In order to read these tags and attribute points to participants, each of the City's 70 recycling collection vehicles will be retrofitted with a RFID reading system. Without the RFID readers, the RecycleBank incentive based recycling program will be inoperable. $708k in EECBG funds will pay for the lease buy-out of the RFID reading system, securing the program's infrastructure. The City anticipates that this innovative program will increase the percent of waste diverted to recycling by 5-10%, which would result in additional 30,000 to 60,000 tons being diverted from trash to recycling each year.

The mayors of this nation bring to this challenge considerable experience and expertise. For years, mayors have been working on the issues of energy, environment and transportation to promote greater sustainability in their communities. Among these many leaders, Conference President, Seattle Mayor Greg Nickels, has led our national movement to focus specifically on reducing greenhouse gas emissions in our communities. Earlier this month, Mayor Nickels welcomed the 1,000th Mayoral Signatory to the Mayors Climate Protection Agreement – Mesa, Arizona Mayor Scott Smith. Each one of these mayors, who collectively represent more than 86 million Americans has committed to reducing their city's greenhouse gas emissions by 7 percent below 1990 levels by 2012. Achievements of these goals has always assumed and expected complementary actions by our states and the Congress.

The Conference of Mayors' Climate Protection Center recently released a new report entitled *The Power of 86 Million Americans: 1000 Mayors Committed to Climate Action – Selected Profiles of Mayoral Leadership*. This report provides selected examples of mayoral actions throughout the nation – whether it involves promoting energy conservation, changing traffic lights to LEDs, retrofitting homes and buildings, or deploying solar and other renewable technologies. These mayors represented both large and small cities in every region of the country.

The EECBG Program was specifically designed to support, and accelerate, such locally-based solutions set forth in the report, activities that mobilize people in their own communities, save money for governments and taxpayers, and create jobs that cannot be outsourced overseas.

Other Noteworthy Programs in S. 1733

In addition to dedicated support for a continued EECBG Program, there are numerous other programs contained in S. 1733 that are good for this nation; policies that will transform our economy, create jobs and reduce greenhouse gas emissions. Philadelphia and other cities have taken a leadership role in many of these same areas. I wanted to highlight a few examples of the benefits of these policies.

Fleet Management (Title I, Subtitle E, Section 154) In 2004, Philadelphia designed a fleet reduction program that was widely celebrated, including recognition by the Kennedy School's Innovation in American Government Awards. At that time, the municipal fleet was reduced by 330 vehicles, facilitated by transportation alternatives that maximized economic returns while reducing environmental impact. The program's key element was contracting with the nonprofit PhillyCarShare (for the first four years and since July 2008 with the for-profit ZipCar) to make car-sharing vehicles available to City employees. To our knowledge, Philadelphia has the largest government car sharing program in the nation and we continue to reduce and reconfigure our municipal fleet to find broader application of car sharing technology. This bill could potentially assist us in our efforts to convert our trash and recycling fleets, helping to lower our greenhouse gas emissions and improve air quality.

Recycling (Title I, Subtitle E, Section 154) - In 2008, Philadelphia developed the largest single-stream recycling program on the east coast, offering weekly curbside service citywide. This simplified approach has already had a dramatic, positive impact on our recycling rate. The current collapse in the recycling market has not deterred us from pursuing the economic and environmental benefits from the program. In the last quarter of 2008, we were paid $44 per ton for our recycled material. Earlier this year we paid $32 per ton, we are now paying 33 cents per ton. While that is disappointing, it is important to note that paying $32 per ton is still cheaper than the $63 per ton we would have to pay to send the material to landfill. We hope that we will be able to utilize the State Recycling Program that is included in S 1733. However, we have also planned to utilize $708,000 of our EECBG funds and $300,000 in other leveraged funds to support an incentive-based recycling program which has a tremendous success in diverting waste from landfills while rewarding our constituents to recycle more.

Taxis (Title I, Subtitle G, Sections 171-173) - We would also like to thank you for including language related to curbing greenhouse gas emissions from taxis in the bill. As you know, emissions from the transportation sector are a significant source of overall emissions for many cities. Giving local governments the ability to control emissions from transportation sources will go a long way to curbing overall emissions.

Solar (Title I, Subtitle F, Section 161) - In 2008, we installed a new solar hot water system at our Riverside Correctional Facility after discovering that the boilers that provide hot water to the facility needed to be replaced. After calculating the payback, we decided to add a solar powered heat exchange system that will provide the primary source of hot water, using gas or oil just as a backup system. Forty-five Solar Panels were installed on the roof and they heat a material similar to antifreeze to 265° Fahrenheit. The heated solution is pumped through coils in well-insulated hot water tanks and the heat exchange produces hot water for bathing, laundry, and cleaning. The additional cost of the solar heating system is expected to pay for itself through lower energy costs in less than nine years. The system's designed lifespan is twenty-five years, which means for two-thirds of its expected life the system will provide hot water at zero energy cost. Over its useful life the solar system will save over $1 million dollars and reduce emissions by over one million pounds of CO_2. There is potential to develop and deploy solar at scale - we have acres and acres of public rooftops in Philadelphia, from schools to water treatment facilities, which could support similar installations. Long-term EECBG funding will help expand and provide some of the financial resources to help pay for these strategic investments.

Building and Housing Retrofits/Job Training (Title I, Subtitle F, Section 164 and Title III, Subtitle A, Part 1) - The City of Philadelphia currently spends $19 million annually on Housing Preservation and Weatherization, $11 million of which is supported by CDBG funds. Administered by the Philadelphia Housing Development Corporation, these funds may be used to provide traditional weatherization improvements, such as attic and wall insulation, window sealing and replacement, and upgraded heating equipment. In addition to basic systems repair, these funds also support emergency repairs and utility payments. The weatherization component of these programs support about 3600 projects per year and could be quickly scaled up with additional funding because the skills requirements for weatherization specialists are relatively easy to attain.

An expanded building and retrofit program contained in this bill could become part of a pipeline to retool Philadelphia's workforce to meet growing demand in the private market for building retrofits, particularly in the home weatherization category. As increasing number of banks and energy service companies offer specialized loans to help homeowners make energy upgrades to their houses, new demand for these services is expected to create new positions for certified weatherization specialists within the next two years. A new job training program developed by the Energy Coordinating Agency (ECA) will certify new weatherization specialists. Some of this training can be completed in as little as two weeks, allowing unemployed or underemployed Philadelphians to transition rapidly into a sector with tremendous opportunity. The total number of trainees, including auditors and installers and other related positions, is expected to be over 800 in the first two years of operation.

It is very important to look at the ECA job training project and others in the national context of the growing, green collar jobs movement. Energy efficiency not only offsets more greenhouse gas emissions than renewables and alternative fuels, it generates significant numbers of domestic jobs. According to the American Council for an Energy-Efficient Economy (ACEEE), "In 2004, an estimated $300 billion, 60% of which was in the buildings sector, was invested in energy efficiency technologies and infrastructure in the United States and those investments made us more productive, saved us money, and supported 1.6 million jobs."

The work of creating a clean energy economy is very labor intensive. These new, green collar jobs require building science, carpentry, electrical, plumbing, sales, and communications skills. These jobs include: insulators, carpenters, heating technicians, energy auditors, and educators, as well as support services, sales, and manufacturing. The good news is that these jobs are a perfect fit for Philadelphia's workforce, and are not transferable overseas. Rather than being dead-end, minimum wage jobs, these are jobs with a bright future that provide access to a continuum of advancement and opportunity.

For example, ECA hires high school graduates at a starting rate of $12/hour plus full benefits. The average salary of their weatherization field staff is $35-40,000/year. Supervisors make more than that average. Salary increases and promotions are increasingly tied to training. For example, the Building Performance Institute certification (an industry standard) translates into a salary increase. ECA is now in the process of having all our inspectors, auditors and supervisors trained and supervised through BPI.

Moreover, just as Weatherization offers an optimal starting place for entry into the labor market, it is also a rich field of opportunity for young companies. Philadelphia's Housing Development Corporation has structured its operations to accommodate small firms, and has had unparalleled success, particularly in providing growth opportunities for minority and women owned firms. This year, roughly half of the firms doing weatherization work for the City will be MWDBEs. Those firms will receive training and technical assistance to help them learn how to sell their energy efficiency skills as products on the private market – the perfect model for small and MWDBE firms to find a foothold in the city's competitive construction marketplace.

How large could such an effort be in Philadelphia? There are approximately 400,000 row homes in our city. Using the estimates cited above, we could raise the energy efficiency of, say, a quarter of these row homes by 20-30% (with insulation, air-sealing, cool roofs, and so on) by investing $2500 x 100,000, or $250 million, over two years. Under our current publicly funded weatherization program, a two-person team of auditors can first survey and later verify a typical project in two half-day sessions and a three-person crew can complete a typical project in one day. Thus, 250 projects would fully occupy five persons over the course of a year, and 50,000 projects would employ at least 1000 people full-time over the course of a year.

At this point, let me emphasize the self-financing aspect of energy efficiency. The stream of savings means that an initial capitalization can be replenished and used to continue the work. The kind of weatherization proposed in the above example (insulation, air sealing, cool roofs) typically has a simple payback of two to three years. In other words, the savings in reduced energy bills will exceed the upfront cost of the improvements in as little as two years, especially when combined with other incentives such as rebates from utilities and tax benefits. Homeowners would have no out-of-pocket costs for the improvements and use the energy savings to pay for improvements. After the payback period, homeowners would get to keep all of the savings from their lower energy bills. With a replenished fund, we could move on the next 100,000 homes. Under the scenario outlined here, we could weatherize every row home in Philadelphia in less than a decade, harvesting a huge return in reduced energy consumption and greenhouse gas emissions while saving our constituents money every year.

Drinking Water Adaptation/Residential Water Efficiency (Title III, Subpart D, Section 381) - Philadelphia's Green Infrastructure Program – Through our "Green City Clean Waters" plan we propose to deploy green space as a public utility by placing thousands of new trees on city streets; increasing the amount of green open space; using pervious pavement on parking lots and playgrounds; building green roofs; and distributing rainwater collection barrels to homeowners. In addition, green infrastructure investments are much more sustainable when we consider their potential as an adaptive approach to climate change and sea level rise. Indeed, investing in new green infrastructure technologies make us more competitive. Green infrastructure demands investments in new green technologies and job skills. *Estimates made for Philadelphia of the value of the environmental, social and direct economic benefits of green storm water infrastructure indicate that there is a dollar-for-dollar return on investment.*

Green stormwater infrastructure creates jobs, which require no prior experience and are therefore suitable for individuals who might be otherwise unemployed or underemployed. These new jobs create a benefit to society in reduced poverty-related costs, in addition to the wages paid to the individual worker. The stabilizing and transforming effects of green stormwater infrastructure in neighborhoods further reinforce and support the benefits of providing employment to a population that is outside the labor force.

As Philadelphia's green stormwater infrastructure program is implemented over the coming years (through the realization of green streets, green public facilities, green schools, etc.), we expect to see approximately 250 people employed in green jobs on an annual basis. Anticipated skills that will be demanded to support the green job economy include tree care, landscaping and expertise in native plants, landscaping design, infiltration testing, system monitoring, natural stream system design, invasive plant removal - an array of skills that currently are not a core component of traditional stormwater infrastructure.

The Philadelphia Water Department (PWD) is currently working with a number of partners, including the Sustainable Business Network, to begin defining skill curriculum and job training as we implement, maintain and monitor PWD's growing inventory of green infrastructure.

Here are a couple of examples of Philadelphia's green infrastructure projects that could be started immediately, with adequate funding:

Green Streets: A second scalable program (up to $2 million ready to go) is our Green Streets program that involves a variety of approaches for all types of streets, from fairly simple strategies like increasing tree cover to more ambitious redesigns that include the use of vegetated sidewalk planters and bump-outs and underground infiltration areas developed in adjacent lands. Over time, this new "green standard" for city streets will touch every neighborhood in a city and result in a completely new urban form requiring $100s of millions in new investment.

Green Corridors: A South Philadelphia main street, the West Passyunk Avenue Business Corridor is home to dozens of small businesses and tens of thousands of residents. We have a $6 million project ready to implement that would create 100 jobs by installing green sidewalks that are landscaped to manage storm water, improved new traffic signals to reduce air pollution caused by congestion, and new energy efficient street lights. This project is a triple win: creating construction jobs, rehabilitating infrastructure that serves small business, and improving air and water quality.

Confronting Energy and Climate Challenges through Sustainable Metropolitan Mobility (Title 1)
Let me now speak to energy and climate challenges from the transportation sector. Reducing dependence on foreign oil, reducing greenhouse gases, and rebuilding and modernizing our nation's transportation infrastructure are priorities for The U.S. Conference of Mayors.

We will not be able to deal with our energy and climate challenges, without confronting this sector.

The transportation sector – its systems and practices – has played a significant part in growing the nation's energy dependency on foreign energy supplies, principally petroleum, and in contributing to higher oil prices and other energy price increases. In 2007, 69 percent of the nation's total petroleum products were consumed in the transportation sector, with petroleum products powering more than 98 percent of the nation's transportation mobility.

As the world's largest energy consumer and largest greenhouse gas emitter, our nation cannot remain economically competitive with the world if we continue down this path. We are being left behind in this area by our world neighbors – from Germany to China – make deep investments in modern transportation systems. This means that going forward, all federally-assisted transportation investments must - as this legislation does - address energy and climate concerns, through needed shifts and reforms in federal policies and programs that emphasize sustainable transportation investments, led by increased investment in public transit, especially electric vehicles powered by sustainable sources, and intercity passenger rail.

This led the Conference to enjoin Siemens and GlobeScan Incorporated to prepare a national study on sustainable metropolitan infrastructure, which included a survey of 140 cities in 40 states. This June

2009 report, *The United States Conference of Mayors Metropolitan Infrastructure Sustainability Study,* assisted the Conference of Mayors in preparing its sustainable transportation platform, *Investing in Livable Cities to Meet 21st Century Transportation Challenges*, in preparation for the next federal surface transportation authorization, which is also under the jurisdiction of this Committee.

An overriding finding of the report was that cities already recognize the importance of infrastructure decisions in helping combat climate change (76 percent) and a strong majority of cities (79 percent) agreed that current federal/state practices must be reformed to give their city greater decision-making power over infrastructure investments. Going forward, mayors, especially in our metropolitan areas, must be empowered to invest federal resources in sustainable transportation.

A compelling local example can be found in Denver Mayor John Hickenlooper, who chairs the Conference Transportation Steering Committee. The mayor was honored this summer at our Providence Annual Meeting, winning our Mayors Climate Protection Award in the large city category for his leadership on rail transit development. Denver's FasTracks initiative is the largest single build-out of rail transit in the nation's history, leading to more than 100 miles of new rail transit service throughout the Denver metropolitan area.

This Committee's support for transportation funding eligibilities in earlier TEA laws helped lay the groundwork for this massive initiative in an earlier project, named T-REX, where a rail transit line was built simultaneously with improvements to Interstates 25 and 225. The FasTracks program and the T-REX project further underscore the importance of your commitment to proceed towards reducing greenhouse gas emissions from transportation, principally through transit, and your upcoming debate on legislation renewing the SAFETEA-LU law.

FasTracks will fundamentally redirect housing and development patterns in this vast and growing metropolitan area. When completed, this investment will reduce driving and congestion, curb oil dependency and greenhouse gas emissions and stimulate a host of related green-oriented investments and the thousands of green jobs that ultimately result from this initiative.

In my own city, we have dense neighborhoods with sidewalks, off- and on-street bike lanes and a far-reaching public transportation system. We can easily walk, bike or ride transit throughout the city limits and beyond. This means that our residents spend less money on gasoline and other car expenses, and emit significantly less greenhouse gases each year than residents in the neighboring suburbs. All of this means that each year, Philadelphians emit 10.2 tons of carbon equivalents per capita versus a national average of 23.6 tons per capita.

And this is only a start...

I want to take a few moments to describe Philadelphia's ambitious steps to further reduce transportation related emissions as described in *Greenworks Philadelphia*, our city's sustainability plan. Philadelphia has already decreased its greenhouse emissions by nearly 10 percent from its 1990 levels, but we recognize that we must do more. We aim to lower our emissions by 2015 to a targeted reduction of 20 percent below 1990 levels.

Over the past five decades, Philadelphia lost jobs and residents. The pulls that caused people to leave our city and others like it were driven in part by government policies that valued highways over transit and new tract housing over older row homes. But, in recent years, Philadelphia has begun to witness a rebirth. In many of our neighborhoods, people and jobs are moving in and private investments are being made. People again view our walkable neighborhoods and public transportation systems as assets to value and nurture. In June, I signed an executive order to formalize a policy that began when I took office: ***a complete streets approach to transportation***.

The Complete Streets policy applies to planning, designing, constructing, maintaining or operating transportation facilities including park roads, drives and paths. The order directs all City departments and agencies to:

1. Give full consideration to the safety and convenience of all users of the transportation system, be they pedestrians, bicyclists, public transit users or motor vehicle drivers;
2. Place a high priority on the safety of those traveling in the public right of way, and in particular the safety of children, the elderly, and persons with disabilities.

The adoption of a *Complete Streets* policy builds on Philadelphia's history of being a great city for walking, biking and riding transit. I expect every City agency to incorporate this policy, constructing a future where it is easier than ever before to walk, bike or take transit. This will enable Philadelphia to really focus on becoming a more livable community.

Although Philadelphia already enjoys a low per capita vehicle miles traveled rate, our goal of reducing miles driven by 10 percent per capita will lower transportation costs even more and bring quality of life benefits to residents. Philadelphia has the type of transit system that many progressive cities are trying to build and gives the city a competitive advantage. I want to recognize SEPTA's efforts to increase transit ridership through further service and capital improvements and its movement to a new fare technology system. Transit Oriented Development investments supported by the City will also help induce more people to use public transit. Finally, the appointment of Philadelphia's first Bicycle and Pedestrian Coordinator will help grow the city's thriving bicycle culture as it seeks to create a city-wide trail network.

Even as new sustainable transportation assets are created, the City must ensure that existing transportation infrastructure is in good repair and are deemed sustainable.

My experience in Philadelphia is characteristic of so many cities and counties that are moving forward with these kinds of investments. However, as reported in the Conference's Sustainability Study, the single greatest infrastructure challenge – raised by three in five cities – is obtaining the funding to meet infrastructure needs. Steps must be taken through this legislation, and through the reauthorization of SAFETEA-LU, to invest in sustainable transportation.

Conclusion

In my statement, I have provided several examples of the energy and climate work underway in the City of Philadelphia. Mayors throughout this nation could similarly testify to their many efforts. All mayors know, and have seen firsthand, how these innovative practices and programs stimulate the economy, create jobs, and protect our environment. At the same time, we know that the potential to do more, including creating millions of new jobs, is vast and that we have only scratched the surface.

We believe this legislation moves the nation forward to the goals of capturing this potential -- a single action that will leave generations that follow with a safer, cleaner and more secure future. The time to act is now. The Clean Energy Jobs and American Power Act you have developed is the right direction at the right time.

I congratulate you, Chairman Boxer, and Members of this Committee for your hard work on this critically important legislation. As you move forward, and we encourage you to do so as expeditiously as possible, the nation's mayors will be supporting your efforts as you move to enact comprehensive energy and climate legislation during this Congress. Thank you for this opportunity to testify on behalf of the Conference of Mayors and the nation's mayors.

Answers from Philadelphia Mayor Michael Nutter

Senator Bernard Sanders
1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Mayor Michael Nutter
We recognize that LDC's are affected differently under this legislation than natural gas providers. Having said that, it is hard to explain to the public why more rigorous criteria apply to natural gas companies, which are often less carbon intensive than electric LDC's. We acknowledge that these LDC's are affected by upstream requirements on generators, but for purposes of promoting some parity -- leading to increased energy efficiency and conservation -- this area should be reviewed further to consider how electric LDC's might be required to satisfy some threshold criteria in this area.

Answers from Philadelphia Mayor Michael Nutter

Senator Amy Klobuchar

1. In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy - from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?

Mayor Michael Nutter

A cap and trade system that predictably ratchets down carbon emission will provide a significant signal to the marketplace, as the increased deployment of renewable energy supplies and energy efficiency technologies will be needed to meet reduction targets. These long-term, clearly-established targets will allow companies to undertake investments to meet the increased demand for carbon-reducing energy products and systems. In addition to this broader framework, there are numerous other commitments in the pending legislation that will provide greater market certainty and demand for products and services. In my testimony, I talked about how the City of Philadelphia is using Energy Efficiency and Conservation Block Grant funds to support and leverage numerous local energy and climate initiatives that are all about homegrown energy projects and technologies. In most cases, these investments rely on contracts with private sector entities or public-private partnerships, as is the case for other cities and counties throughout the U.S. Under the legislation, the annual commitment of EECBG resources, as S. 1733 provides, will also provide considerable and sustained impetus for increased demand for homegrown energy services and products.

Senator BOXER. Thank you so much, Mr. Mayor.

Our next speaker is Kate Gordon, Senior Policy Advisor to the Apollo Alliance.

Welcome.

STATEMENT OF KATE GORDON, SENIOR ADVISOR, APOLLO ALLIANCE

Ms. GORDON. Thank you, Chairman Boxer and members of the committee. Thanks so much for inviting me here today to talk about how a strong comprehensive energy and jobs bill can bolster the American economy, usher in a new era of sustainable growth and create millions of high quality jobs.

After September 11th, this country faced a recession that we combated through unsustainable investments in financial paper and real estate. The next recession, the one we are in now, is much deeper and is hitting Americans much harder. Since December 2007, the ranks of the unemployed have increased by over 7 million people and the unemployment rate now stands at close to 10 percent.

While the investments made through the Recovery Act successfully staved off deep economic crisis, the American economy is still in search of its next economic generator. The need for an economic strategy that keeps our workers in their jobs while creating a whole host of new, good jobs has never been so urgent.

Clean energy investments are the key to America's new sustainable growth strategy. Despite inconsistent support from the Federal Government, these industries have already proven themselves to be growth areas for the future. Investments in wind, solar photovoltaic and biofuels grew by 50 percent between 2007 and 2008 and are expected to exceed $325 billion within a decade.

Jobs in wind energy generation grew by 23 percent, solar generation by 19 percent between 1998 and 2007, outpacing the 3.7 percent job growth in the rest of the U.S. economy experienced over the same period. But until the Federal Government truly commits to a low carbon future, investment and employment in these industries will just never grow to the scale needed to truly drive an economy-wide resurgence.

While many of the pioneering renewable energy technologies were invented here, today American companies control only 6 of the world's top 30 companies in solar, wind and advanced batteries. Our European and Asian competitors have moved aggressively to support renewable energy and in the process have developed greater renewable capacity as well as stronger industrial growth. In fact, China's leaders are investing $12.6 million an hour to green their economies. As David Sandalow, Assistant Secretary for Policy and International Affairs at the Energy Department recently put it, if they invest in 21st century technologies and we invest in 20th century technologies, they will win.

Our clean tech industry is impressive, but by global standards we are playing in a garage band. And we must—and should—become Bruce Springsteen.

By taking decisive action to limit and reduce climate pollution, the Clean Energy Jobs and American Power Act will send a clarion call through the world that America is ready to step up and take action to curb climate change. It will also send the signal many of companies have been waiting for, that this country is serious about opening up vast new markets for clean energy investment. Where there is clean energy investment, clean energy jobs will follow.

The Apollo Alliance has long made the case that investment in clean energy is not just good environmental policy, it is good economic development policy. Recent studies support these claims. Jobs in the clean energy economy have grown nearly 2 and half times faster than overall jobs in the economy. An analysis by the Center for American Progress and the Political Economy Research Institute found that an investment package combining the Recovery Act and House bill on climate would create a net 1.7 million new jobs in the economy.

These employment opportunities, it is important to note, will be across all sectors of the economy and will provide a unique opportunity to rebuild our middle class through job creation in sectors particularly hard hit by recent recessions.

Fully 55 percent of all new jobs in these emerging industries are projected to be in the manufacturing and construction industries. These are industries that provide a living wage and high-quality jobs for the 68 percent of working Americans who do not have a 4-year college degree. Jobs in manufacturing and construction are also more likely to serve middle-skill workers and are more likely to be unionized, providing higher wages, better benefits and greater access to job training.

In addition to providing market certainty for clean energy investments through predictably decreasing limit on carbon emissions, this bill makes important investments in expanding renewable power and energy efficiency projects, domestic manufacturing of efficient vehicles, and green collar jobs programs.

And my fellow panelists have said some important things about these provisions, and I would highlight some of the provisions that they talked about, particularly those that funnel money through State and local governments. We know that this is one of the best ways to stimulate the American economy. The bill contains the SEED accounts, the Energy Efficiency Conservation Block Grant Program, and the money for clean vehicles, which will provide needed incentives to scale up our industries to meet growing demand.

We look forward to the coming weeks when there will be opportunities to make this bill more comprehensive and to strengthen several of its critical provisions. I would particularly point to a couple of areas.

One, while the act includes important cost protections for energy intensive industries, it should also invest directly in thousands of other domestic manufacturing firms ideally placed to meet new clean energy technology demands. And Apollo has worked very hard on this issue, talked to hundreds of small manufacturing firms across the country who tell us they need investments to retool and become part of these industries. We encourage you to include IMPACT and Senator Bingaman's Restoring American Manufacturing Leadership in this bill.

We also applaud the Climate Change Worker Assistance Program——

Senator BOXER. Could I ask you to——

Ms. GORDON. Yes, I am almost done.

And we would encourage you to also include community economic development provisions in that bill.

As the committee considers this bill, please, we encourage you to put the American economy on the road to a stronger economy through investments in these clean energy and good jobs in American workers. The path we are on now, it is important to note, is not working. It is leading to unemployment, environmental degradation and dependence on other countries.

With your leadership, we know we are up to the challenge——

Senator BOXER. I am sorry. All right. Thank you.

Ms. GORDON. Thank you so much.

[The prepared statement of Ms. Gordon follows:]

Kate Gordon
Senior Advisor, Apollo Alliance
Remarks to U.S. Senate
Committee on Environment and Public Works
Wednesday, October 28, 2009

Chairwoman Boxer and members of the committee, thank you for inviting me here today to talk about how a strong, comprehensive energy and jobs bill can bolster the American economy, usher in a new era of sustainable growth, and create millions of high quality jobs.

This Congress has taken the critical need for a sustainable growth strategy seriously. In June, the House passed the American Clean Energy and Security Act, which uses a price and a cap on pollution as the centerpiece of a comprehensive climate and energy strategy, and sends a strong signal that America is ready to tackle global warming – and become a global leader in new technologies in the process. Here in the Senate, the Energy and Natural Resources Committee took the important step of passing the American Clean Energy Leadership Act, which has at its core the notion that our economic competitiveness and national security demand a significant shift to renewable power, and that our companies and consumers need support as they learn how to develop that power and use it more efficiently. That Act also created the Clean Energy Deployment Administration, a new green bank that will help overcome the financing barriers faced by entrepreneurial energy technology companies.

And now it is this Committee's turn, in perhaps the most important moment of the current climate and energy debate. I am honored to be here to discuss this critical piece of a comprehensive strategy to reduce climate emissions and create good jobs, the Clean Energy Jobs and American Power Act of 2009.

America Needs a New Sustainable Economic Growth Strategy

After September 11, 2001, this country faced a recession that we combated through unsustainable investments in financial paper and real estate. The next recession, the one we're in now, is much deeper and is hitting Americans much harder. Since December 2007, the ranks of the unemployed have increased by over seven million people, and the unemployment rate now stands close to ten percent. While the investments made through the American Recovery and Reinvestment Act (ARRA) successfully staved off deep economic crisis, the American economy is still in search of its next economic generator. The need for an economic strategy that keeps our workers in their jobs while creating a whole host of new, good jobs has never been so urgent.

The Apollo Alliance and our partners in the labor, environmental, social justice and business communities believe that in order to emerge from our current economic crisis, we must make a series of strategic, targeted sustainable investments to create these new, high quality jobs in the clean energy economy.

Last fall, we released our *New Apollo Program*, a proposal for a comprehensive suite of federal investments to build the clean energy economy by leveraging America's strengths, such as our can-do spirit, our industrial infrastructure, our skilled workforce, and our world-class educational system. This program called for a federal investment of $500 billion over ten years to revolutionize how we produce and use energy – an investment that would create over 5 million new jobs. It also called for a cap and price to be put on carbon pollution. The Apollo Alliance was one of the first organizations to recognize early on that a market-based system to limit carbon emissions is an essential component of any comprehensive strategy to generate growth in the clean energy economy, because it creates new markets for low-carbon products while providing certainty for private investments into the renewable and energy efficiency industries.

Despite inconsistent support from the federal government, these industries have already proven themselves to be growth areas for the future. Investments in wind, solar photovoltaic, and biofuels grew by 50 percent between 2007 and 2008 and are expected to exceed $325 billion within a decade.[i] And, jobs wind energy generation grew by 23 percent and solar energy generation by 19 percent between 1998 and 2007, outpacing the 3.7 percent job growth in the rest of the U.S. economy experienced over the same period.[ii]

Until the federal government truly commits to a low-carbon future, however, investment and employment in these industries will never grow to the scale needed to truly drive an economy-wide resurgence. While many of the pioneering renewable energy technologies were invented here, today American companies control only six of the world's top 30 companies in solar, wind and advanced batteries.[iii] And since 1997, the U.S's green trade balance has moved from a $14.4 billion surplus to a deficit of nearly $9 billion last year.[iv] Our European and Asian competitors have moved aggressively to support renewable energy and, in the process, have developed greater renewable capacity as well as stronger industry growth. In fact, China's leaders are investing $12.6 million every hour to green their economy.[v] As David Sandalow, assistant secretary for policy and international affairs at the Energy Department recently put it, "if they invest in 21st-century technologies and we invest in 20th-century technologies, they will win,"[vi]

Our clean tech industry is impressive, but by global standards we are still playing in a garage band. We need to become Bruce Springsteen. The bill currently before you opens that door.

Sustainable Growth Means Sustainable Jobs

By taking decisive action to limit, and steadily reduce, climate pollution, the Clean Energy Jobs and American Power Act will send a clarion call throughout the world that America is ready to step up and take action to curb climate change. It will also send the signal many of our clean tech and clean manufacturing companies have been waiting for, that this country is serious about opening up vast new markets for clean energy investments. And where there is clean energy investment, clean energy jobs will follow.

Since its founding in 2003, the Apollo Alliance has made the case that investment in clean energy is not just good environmental policy, but also good economic development policy. Recent studies support these claims: jobs in the clean energy economy have grown nearly two and a half times faster than overall jobs in the economy between 1998 and 2007.[vii] An analysis by the Center for American Progress and the Political Economy Research Institute found that an investment package combining the Recovery Act and the American Clean Energy and Security Act would create a net of 1.7 million new jobs in the U.S. economy.[viii]

These employment opportunities will be across all sectors of the economy, and will provide a unique opportunity to rebuild the nation's middle class through job creation in sectors particularly hard hit by the recessions. Fully 55% of all new jobs in the emerging renewable energy and efficiency industries are projected to be in the manufacturing and construction sectors, sectors that provide living wage, high quality jobs for the 68% of working Americans who lack four-year degrees.[ix] Jobs in manufacturing and construction are more likely to serve these middle-skill workers, and are more likely to be unionized, providing higher wages, better benefits and greater access to job training. [x xi]

The Recovery Act served as an important down payment on the creating high quality jobs in the new energy economy, by investing more than $100 billion in renewable energy development, transportation projects, energy efficiency and weatherization, technological research, and workforce training and education. These investments have already spurred new demand for efficient products, and for workers with the skills to make and install these products.

Sunrise Solar in St. John, Indiana provides a perfect illustration of the power of clean energy investments to create real American jobs. Sunrise Solar makes solar-powered attic fans, a technology that saves homeowners 30 percent on the cooling portion of their utility bill. It is a truly American business story: owner Bill Keith launched the business in 2003 out of his garage, and is now planning to open a second production facility next year. Sales have increased, in part, due to a 30 percent tax credit included in the Recovery Act for the purchase of energy efficiency products. Sunrise Solar is creating good jobs, with decent pay and benefits, and because Bill uses local suppliers wherever possible, his company also creates new jobs throughout the local economy.

Sunrise Solar is one company. The Clean Energy Jobs and American Power Act has the potential to create tens of thousands of these companies, and millions of new jobs, across the country. These jobs will be obviously be supported by investments in the bill, but those public dollars are intended to drive a far greater number of private investments, which will ultimately provide the financial backbone for the new clean energy economy.

The Clean Energy and American Power Act is a Critical Step Toward Sustainable Growth

In addition to providing market certainty for clean energy investments through a predictably decreasing limit on carbon emissions, the bill also makes important investments in expanding renewable power and energy efficiency projects, domestic manufacturing of efficient vehicles, and green-collar job training programs.

We know that the best way to stimulate the American economy is to funnel public money through state and local governments, which have the best sense of their own economic growth potential and investment opportunities. The Clean Energy Jobs Act provides significant and sustained funding to states to invest in renewable energy and energy efficiency through the State Energy and Environment Development (SEED) accounts. Across the country, we have already seen state-level clean energy investments generate significant employment opportunities. For instance, a 33,000-acre wind farm developed by Ohio-based Vision Energy will need 300 construction workers over a 12-month period and eventually will hire 30 to 40 full-time, highly trained technical employees. To respond to the need for trained wind turbine installers and technicians, Kankakee Community College in Illinois is working with the local Workforce Investment Board and the wind project developer to develop a training curriculum to prepare local residents for the new employment opportunities.

The Clean Energy Jobs Act provides continued and direct funding for the Energy Efficiency and Conservation Block Grant program, while also guaranteeing a share of state funding for the Retrofit for Energy and Environmental Performance program. Efficiency programs being administered nationwide are driving innovative programs at the local level which save consumers money while reducing energy use. The city of Chicago is already using a portion of its Energy Efficiency Community Block Grant funding to experiment with a model that tackles one of the toughest program design challenges in building energy efficiency: including low-income renters. The program has promoted collaboration between community lenders and energy service companies to provide low income renters with energy efficiency services, while also leveraging private resources. [xii]

The Clean Energy Jobs Act focuses not only on the electricity sector, but on the transportation sector as well. The Act provides funding for the transit vehicles and infrastructure, and for the next-generation vehicles, that are necessary to reduce our reliance on foreign oil and address the 30 percent of total greenhouse gas emissions generated by the transportation sector. The Clean Energy Jobs Act creates a new allocation program which directs funding to states, transit agencies, and metropolitan planning organizations to fund transportation projects that reduce greenhouse gas emissions. These projects create jobs: transit projects tend to generate nine percent more jobs per dollar spent than road and bridge repair and maintenance projects, and nearly 19 percent more jobs than new road or bridge projects.[xiii] When done at scale, these projects often create union jobs that pay family-supporting wages and benefits. Importantly, the bill does not look only at transportation operations and installation; it also helps to fund American vehicle manufacturing. The Clean Vehicle Technology Fund would bolster the domestic development and manufacture of light- and heavy-duty plug-in electric vehicles. Investments in the vehicle batteries through the Recovery Act have already proven to be significant job creation engines. Advanced battery technology grants to 11 companies in Michigan are expected to create 6,800 new jobs in the next 18 months and up to 40,000 jobs over the next 11 years.[xiv]

And, the Clean Energy Jobs Act recognizes that our workforce is the backbone of the clean energy economy, by investing in green jobs training programs to ensure that workers are prepared for new and higher-skilled jobs in the electricity, energy, retrofitting, and transportation sectors. As states and cities continue to experiment with new methods of providing energy efficiency services to homeowners, the need for high-quality trained workers continues to grow. In Portland, Oregon, Oregon Apollo chair and AFL-CIO Secretary-Treasurer Barbara Byrd worked with Green For All and the city of Portland in facilitating a process involving dozens of stakeholders from a diverse set of interests including labor, business, utilities, and the community that resulted in an innovative community workforce agreement. It will ensure that contractors participating in Portland's innovative Clean Energy Works program utilize workers from job training programs. This provision ensures that qualified, historically underrepresented contractors and workers benefit from the thousands of high-quality, family-supporting jobs created by this program, and underscores the need for a stronger workforce training infrastructure for the green economy nationwide. The Clean Energy Jobs and American Power Act expands total funding for provisions of the Green Jobs Act and extends the investment for an additional two years.

Turning the Clean Energy Jobs and American Power Act into a truly Comprehensive Energy and Climate Program for America

While we truly applaud the efforts of Senators Kerry and Boxer in advancing this bill, there are also areas where we feel the bill could be strengthened if it is to fully capture the potential of the clean energy economy.

First, while the Clean Energy Jobs Act includes important cost protections for energy intensive industries and targeted investment in clean vehicle manufacturing, it should also invest directly in the thousands of other domestic manufacturing firms ideally placed to meet new clean and efficient energy technology demands. Currently, America imports more than 70 percent of clean energy components, at the same time that our heartland states are hemorrhaging manufacturing jobs. As this committee moves forward to work with others on a comprehensive energy and climate strategy, we encourage you to look to some of the important provisions to invest in American manufacturing contained in other Senate legislative proposals and bills, including Senator Brown's Investments for Manufacturing Progress and Clean Technology Act (IMPACT), and Senator Bingaman's Restoring America's Manufacturing Leadership through Energy Efficiency Act. The programs in these bills, including financing for small and medium sized manufacturers to retool, retain workers, and become more energy efficient themselves, are vital components to ensuring that the clean energy products demanded by the new energy economy can be made in America.

Second, while the bill increases investment in renewable energy and energy efficiency, your committee could not, for jurisdictional reasons, incorporate the renewable electricity and energy efficiency standards contained in the Energy and Natural Resources Committee's American Clean Energy Leadership Act. As the bill moves forward, we encourage Committee members to work closely with other committees incorporate a strong renewable energy standard into the legislation. These important standards are key components to ensuring continued deployment of renewable energy and energy efficient systems, as well as creating jobs in the construction and manufacturing sectors. In the *New Apollo Program*, the Apollo Alliance and its partners called for producing a quarter of the nation's power through renewable and recycled energy resources. Under a national RES of 25% by 2025, the Renewable Energy Policy Project projects that there could be more than 850,000 new manufacturing job opportunities in existing component parts firms across the U.S.[xv]

In addition to setting strong national goals for renewable energy generation and conservation through efficiency, the Committee should consider two other provisions which would guarantee further investment into efficiency. First, the Senate should require that at least one-third of allowances allocated to local distribution companies (LDCs) are used to specifically support energy efficiency projects, and should target these efficiency efforts toward low-income consumers who most need the resulting reductions in their electricity bills. Also, the Senate should strengthen the building codes provision by specifying target energy use reductions of at least 30 percent by 2010, as contained in both ENR's American Clean Energy Leadership Act and in the House climate bill.[xvi]

Finally, we applaud the inclusion of the Climate Change Worker Assistance program to help transition workers in carbon-intensive industries, but urge you to go further by providing economic development assistance for those communities that are currently dependent on those industries. While change will not come overnight, the fact is that, as the EPA said in its analysis of your legislation last Friday, "[T]he cap-and-trade policies outlined [here] would transform the way the United States produces and uses energy."[i] Every time America has experienced a similar major economic shift, we have recognized the need to lend a helping hand to those who may be negatively affected. When soldiers came back from World War II and re-entered the economy, we passed the GI Bill to help them transition into civilian life. Recognizing that individual worker assistance is only part of the solution, the American Recovery and Reinvestment Act added community economic development to the Trade Adjustment Assistance program. Similarly, we must help communities that are dependent on carbon-intensive industries to develop comprehensive strategic plans for community redevelopment, which will help ease the transition from their reliance on carbon intensive industries, diversify their employment opportunities, and provide needed support for environmental remediation and public infrastructure construction projects.

As the committee considers the American Clean Energy Jobs and American Power Act of 2009, we encourage you to put the American economy on the road to a stronger economy through investments in clean energy, good jobs, and American workers. The path we are on now is not working – it is leading to unemployment, environmental degradation, and dependence on other countries for our carbon-intensive *and* low-carbon energy resources. In a time of unparalleled economic uncertainty, we ask committee members and members of the broader Senate to choose a different path, and choose it now.

With your leadership, we know this country is up for the challenge. Let's take this garage band out on the road.

Thank you.

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[i] Mankower, J. et al. *Clean Energy Trends 2009* (Clean Edge, March 2009). www.cleanedge.com/reports/reports-trends2009.php

[ii] *The Clean Energy Economy.* (Pew Charitable Trusts, June 2009). www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf

[iii] Testimony by John Doerr before the Senate Committee on the Environment and Public Works, January 7, 2009, available at: http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=df8869c6-c972-417b-b0a7-14b09d8c50bc

[iv] Sherradan, S. and Peuquet, J. *Green Trade Balance.* (The New America Foundation, June 2009). www.newamerica.net/publications/policy/green_trade_balance

[v] Furnas, Ben. *We Must Seize the Energy Opportunity or Slip Further Behind.* (Center for American Progress, April 2009). www.americanprogress.org/issues/2009/04/pdf/china_energy.pdf

[vi] Mufson, Steve. "China Steps Up, Slowly but Surely". *Washington Post*. October 24, 2009. www.washingtonpost.com/wp-dyn/content/article/2009/10/23/AR2009102304075.html
[vii] *The Clean Energy Economy.* (Pew Charitable Trusts, June 2009). www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf
[viii] Pollin, R. et al. *The Economic Benefitsof Investing in Clean Energy.* (Center for American Progress, June 2009). http://www.americanprogress.org/issues/2009/06/pdf/peri_report.pdf
[ix] American Community Survey, 2005-2007 data; Bivens, J.; Irons, J. and Pollack, E. *Green Investments and the Labor Market* (Economic Policy Institute, April 2009).
[x] Ibid.
[xi] Madland, D. and Walter, K. *Unions are Good for the American Economy* (Center for American Progress, February, 2009). www.americanprogressaction.org/issues/2009/02/efca_factsheets.html
[xii] *Expanding Retrofits With Private Financing: Chicago's Multi-Family Energy Retrofit Program.* (The Brookings Institution, July 2009). www.brookings.edu/~/media/Files/rc/papers/2009/0723_arra_chicago_retrofit/0723_arra_chicago_retrofit_profile.pdf
[xiii] New Apollo Program. (Apollo Alliance, September 2008). http://apolloalliance.org/wp-content/uploads/2009/03/fullreportfinal.pdf
[xiv] "Granholm Says Advanced Battery Grants Will Create Thousands of Good-Paying Jobs in Michigan". Press Release, Office of Governor Jennifer M. Granholm. August 6, 2009. http://www.michigan.gov/gov/0,1607,7-168--219571--,00.html
[xv] *How to Revitalize America's Middle Class with the Clean Energy Economy* (Blue Green Alliance, June 2009). www.repp.org/articles/BGA_Repp.pdf
[xvi] For discussion of building code provisions in ACES and ACLEA, see: *ACELA Summary & Comparison to the ACES Act.* (Pew Center on Global Climate Change, 2009) http://www.pewclimate.org/docUploads/acela-summary-and-aces-act-comparison.pdf .
[i] Economic Impacts of S.1733: The Clean Energy Jobs and American Power Act. (Environmental Protection Agency, October 2009). www.epa.gov/climatechange/economics/pdfs/EPA_S1733_Analysis.pdf

MEMORANDUM

Date: October 29, 2009

To: Sen. Bernard Sanders

CC: Hon. Barbara Boxer, Chairman, and Hon. James Inhofe, Ranking Member, Senate Environment and Public Works Committee

From: Kate Gordon, Apollo Alliance

RE: Question regarding allocations for energy efficiency

In response to the following question regarding allocations for energy efficiency:

> "We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDCs under this legislation, just as this legislation does for the natural gas allocation?"

The Apollo Alliance has always supported large-scale investments in energy efficiency. Making our homes and buildings more efficient represents the 'low-hanging fruit' in reducing carbon emissions – with support for programs like Efficiency Vermont that seek to reduce energy consumption across all sectors of the state's economy, we can create high-quality jobs, save homeowners and businesses money, and make significant and immediate reductions in carbon emissions

We applaud the Committee's inclusion of a requirement that no less than one third of allowance allocations for natural gas consumer be used for energy efficiency programs. Recently, the Apollo Alliance joined a number of national organizations in calling for one-third of total allocations to electric utility LDCs to be dedicated to energy efficiency investments as well. Implementing such a requirement would result in over $100 billion of new investment in energy efficiency and create more than 900,000 new construction and energy services jobs by 2020. [1]

[1] Green For All. "Learn More: 1 Million Clean Energy Jobs, Not Utility Give Aways". http://www.greenforall.org/what-we-do/working-with-washington/american-clean-energy-and-security-act/more-information-about-the-electric-utility-amendment

MEMORANDUM

Date: October 29, 2009
To: Sen. Amy Klobuchar
CC: Hon. Barbara Boxer, Chairman, and Hon. James Inhofe, Ranking Member, Senate Environment and Public Works Committee
From: Kate Gordon, Apollo Alliance
RE: Questions regarding market certainty for energy projects and the role of Renewable Energy Standards

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In response to the following question regarding market certainty for energy projects:

> "In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy – from biofuels, to biomass, to wind, solar, geothermal, and hydropower. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on the bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?"

The Apollo Alliance is a strong supporter of both public and private sector investment in renewable energy technologies and projects. We applaud Minnesota's innovation and commitment to expanding the state's renewable energy resources, particularly the state's strong Renewable Portfolio Standard combined with loans and incentives for investment in renewable energy. We agree that consistent incentives which apply to a broad range of technologies and project sponsors are vital tools for stimulating private investment in both small and large-scale renewable energy projects.

By placing a cap on carbon emissions, the current draft climate bill creates a significant incentive to invest in both energy efficiency and renewable energy projects and technologies. This cap, decreasing at an established pace, provides certainty that the market for clean energy technologies will continue to expand. Placing a price on carbon, and auctioning allowances, also generates an important source of revenue which can and should be invested in research and development, energy efficiency, and renewable energy generation, among others. These investments will stimulate demand for clean energy products and components, providing further opportunities for domestic firms that produce, install, and maintain renewable energy systems.

However, the current draft of the bill could go further in creating certainty in the market for clean energy investment. In addition the cap on pollution, the Apollo Alliance strongly supports the integration of a Renewable Energy Standard into the Clean Energy Jobs Act, such as the proposal integrated into the American Clean Energy Leadership Act.

In addition, we strongly support investments in the clean domestic manufacturing sector to ensure that the renewable energy systems demanded by the new energy economy are made here. Currently, over 70 percent of all renewable energy systems are manufactured overseas. Through strategic investments in manufacturing efficiency and retooling, such as the provisions contained in Investments for Manufacturing Progress and Clean Technology Act (S.1617), and the Restoring America's Manufacturing Leadership through Energy Efficiency Act (S.661), we help reverse this trend and ensure our investments in help to create jobs in the domestic manufacturing sector.

In response to the following question regarding the role of Renewable Energy Standards:

> "Ms. Gordon, in your testimony you mention that under a national RES of 25% by 2025, there could be more than 850,000 new manufacturing job opportunities in existing parts firms across the U.S. Can you expand on the role of a renewable energy standard in an energy and climate change bill? How will the RES complement the pollution reduction and investment mechanism?"

In *The New Apollo Program*, the Apollo Alliance calls for a national Renewable Energy Standard of 25% by 2025, combined with a mechanism that places a cap on carbon and auctions allowances to generate revenue that can be invested in clean energy. While a pollution reduction and investment mechanism as detailed in the Senate draft climate bill will effectively reduce emissions and stimulate a shift toward cleaner and more efficient energy and industrial technologies, it must be combined with a strong Renewable Energy Standard that will stimulate specific investment in renewable technologies like wind, solar, geothermal, and biomass, among others. Establishing this standard specifically directs both those emitters covered by the pollution reduction requirement, and those that are not, to develop and expand renewable energy resources sufficient to meet a significant portion of our current and future energy needs.

Senator BOXER. Thank you.

And now, that completes the Democratic witnesses. And now we have the Republican witnesses.

The first one is Bill, I want to make sure I pronounce it right, Mr. Klesse.

Mr. KLESSE. Klesse.

Senator BOXER. Klesse. Bill Klesse, Chairman and CEO of Valero Energy Corporation.

Welcome, sir.

STATEMENT OF BILL KLESSE, CHIEF EXECUTIVE OFFICER, PRESIDENT, AND CHAIRMAN, VALERO ENERGY CORPORATION

Mr. KLESSE. Thank you, Madam Chairman, Senator Inhofe and other committee members. I am honored to be here today——

Senator BOXER. Is your microphone on, sir?

Mr. KLESSE. Yes. Representing an independent refiner, Valero Energy Corporation. And also, I come before you as the Chairman of the National Petrochemical & Refiners Association, which represents over 450 businesses that make reliable and diverse products for all Americans.

The implications of this legislation are devastating for the American people and for the American refining and petrochemical industries. One of our chief concerns is that this legislation provides foreign refiners and petrochemical operations a competitive advantage to American businesses.

You must remember that we are a global business. India, China, Europe and other countries provide intense competition to American refiners. With the recession, increasing regulation and now the potential costs associated with this legislation, results are devastating, not only to our businesses, but to the millions of Americans who work in or around this industry.

Today, refiners and petrochemical plants are idling units, closing facilities, hundreds of jobs are being lost. This legislation will force U.S. refiners to further reduce or close even more operations. It is entirely counterproductive to lifting our economy out of this recession, and it will drive refining production to other countries.

In addition to exporting one of the last great American manufacturing sectors that is globally competitive, you will simply be transferring the carbon dioxide emissions overseas, making the overall impact on the environment negligible or even worse.

Are we a country willing to ruin the American industry that literally fuels our economy? The legislation has nothing to do with national energy security. In fact, given the negative effect this legislation would have on our industry, we are actually talking about a threat. America's safety is threatened by increased imports of refined products and the Pentagon's ultimate reliance on military fuels produced in unstable regions of the world.

As to the consumer, this legislation will impose huge new costs. Close to 3 million tons of CO_2 are emitted each year transporting people and goods across our great Nation. Even at a low carbon price of $20 per ton, the refining sector will have to purchase $63 billion in carbon credits every year. In addition to placing an unmanageable financial strain for cash on refiners, consumers will feel much of this burden in the form of higher fuel costs.

We all desire a broad menu of safe, reliable, low cost fuels. Today's vehicles operate primarily on traditional gasoline and diesel fuel. Emerging technologies will be part of the fuel mix, but are still years away from commercial viability and affordability.

This legislation attempts to raise all product prices so that other less economic products look better to the consumer. Is this really fair to the American consumer or to our industry? As diesel fuel prices increase, what happens to the jobs in railroads and trucking?

The NPRA is not opposed to energy policies that promote alternative fuels. We support a balanced and realistic energy policy rooted in true fuel diversity. We must invest in future technologies, but not at the expense of the economic fuels that we have today.

My company has a 50-megawatt wind farm in the Texas Panhandle next to our refinery. We are also very active in the ethanol business. We support programs that include meaningful global participation and ensure that the U.S. can continue to compete in the global markets. We support a national program with realistic carbon emissions. However, policies should not pick winners and losers.

We support the actions of this committee. The adverse impacts of the proposed legislation to our workers are staggering. Valero refinery employees live in your State, Chairman Boxer, Senator Inhofe, and other members of this committee, Delaware, New Jersey, Tennessee and Louisiana. These are real people. Many did not graduate from college, instead learned a critical skill. They work hard. These are people with families. They educate their kids, they pay taxes, they have good health benefits and solid retirement. They are the heart of the country. They are the middle class. We are in favor of green jobs, but not at the expense of the heartland red, white and blue jobs.

Valero and the NPRA and its members are ready to work with you and to create a policy that will protect the interests of the American consumer, preserve good paying jobs, enhance U.S. competitiveness in the world and achieve a desired environmental objective.

Thank you.

[The prepared statement of Mr. Klesse follows:]

NPRA

Written Statement of

Bill Klesse
Chief Executive Officer, President and Chairman
Valero Energy Corporation

on behalf of

National Petrochemical and Refiners Association

on

S. 1733 "The Clean Energy Jobs and American Power Act"

before the

Committee on Environment and Public Works
U.S. Senate

October 28, 2009

Introduction

Good morning, Madam Chair and Senator Inhofe. My name is Bill Klesse, and I am the Chief Executive Officer, President and Chairman of Valero Energy Corporation, an independent refiner based in San Antonio, Texas. Valero has 22,000 employees, 5,800 branded marketing sites and 16 refineries in the United States, Canada and the Caribbean with a combined capacity of 3 million barrels per day (BPD). Valero is also a leader in alternative fuels and energy. We have seven ethanol plants in the Midwest with a combined capacity of 780 million gallons per year, a 50-megawatt wind farm in the Texas Panhandle, and seed investments in next-generation ethanol and biodiesel.

In addition to my role at Valero, I come before the committee today in my capacity as Chairman of NPRA, the National Petrochemical & Refiners Association, which represents more than 450 businesses that provide Americans with a reliable and diverse supply of products and services used daily at home, at work and at play. These products include gasoline, diesel fuel, home heating oil, jet fuel, lubricants and the chemicals that serve as "building blocks" in manufacturing. We make the products that get people to work, that enable us to trade our goods and services, and that provide critical building blocks for pharmaceuticals. What we produce enhances every American's quality of life.

NPRA and I appreciate the opportunity to offer our perspective on S. 1733, the "Clean Energy Jobs and American Power Act." As you and your colleagues understand, the implications of this legislation are far-reaching. Through my testimony today, I hope to convey to the committee, and more broadly to the American public, what these implications could mean for decades to come.

At stake are millions of American jobs, our national energy security, and the health of our economy. In the midst of a severe recession and fears of a jobless recovery, we must stay focused on these three concerns, particularly in the face of a competitive global marketplace that quickly could compromise our nation's stronghold in the energy industry.

Today's Challenges

Before outlining our perspective on pending cap-and-trade legislation, I'd like to summarize briefly the current situation for domestic refiners.

As the members of this committee know, we already live in a carbon-restricted economy. Witness the impact the recession is having on emissions and domestic energy production. EIA Administrator Richard Newell said recently that "[s]everal factors contribute to a projected reduction of nearly 6 percent in U.S. carbon dioxide emissions from fossil fuel use in 2009, primarily associated with the economic downturn."[1]

The Energy Policy Research Foundation reported this month that even before domestic refiners face rising costs from carbon emissions, they will face a higher cost structure and rising international competition that threatens 2 million of the current 17.5 million barrels a day of domestic operable capacity with permanent closure.

This impact is already being felt today. One large independent refiner has announced that it will idle a New Jersey refinery while it weathers a decline in transportation fuel demand, resulting in more than 500 jobs lost. Meanwhile, Valero has been forced to close our facility in Aruba, idle units in Delaware, and reduce jobs in New Jersey and elsewhere within our company. All are casualties of the recession and a domestic policy agenda that leaves refiners at a distinct disadvantage.

[1] Timothy Gardner and Jim Marshall, "U.S. 2009 carbon emissions to fall 5.9 percent: EIA," Reuters, October 6, 2009

The objective of this Congress and the Administration should be to seek *new means* for reducing emissions *without causing harm to the domestic economy*. The approaches being discussed in Washington are entirely counterproductive to lifting our economy out of the recession, reducing the staggering national unemployment rate, and even reducing global greenhouse gas emissions. S. 1733, like its House companion, H.R. 2454, would only exacerbate our current challenges by forcing U.S refiners to further reduce or even close operations in the face of rising costs and unrealistic emissions reduction targets.

For example, the direct impact to Valero refineries will be staggering, even with a price for carbon at $20 a metric ton -- the low end of the projected range. For our stationary source emissions alone, the cost at our Delaware City refinery would be an additional $40-$80 million a year ... at Benicia, California, an additional $30-$60 million annually ... at Corpus Christi, Texas, $45-$92 million a year. In addition to these stationary emissions costs, both the House and Senate bills hold refiners accountable for emissions from our fuel products after they reach our consumers' hands. For Valero alone, these consumer emissions equate to 300 million metric tons per year. At $20 a ton, that's an additional $6 billion a year.

Industrywide, we estimate the compliance cost for process emissions, with carbon at $20 a ton, to be $4.1 billion a year, and the cost of consumer emissions to be $63 billion a year, for a total cost to domestic refiners -- and potentially consumers -- of more than $67 billion a year.

S. 1733 will drive domestic gasoline and diesel production offshore, resulting in lost jobs for American workers and the outsourcing of our nation's energy security to regions of the world that do not follow such stringent environmental protections. Simply put, this legislation will export carbon dioxide emissions to other countries and take with it American jobs. For that reason, among others, we oppose both bills in their current forms.

Valero is an independent refiner, which means we do not have oil exploration and production. Valero buys all of its oil on the open market. Therefore, Valero's profit is determined by the difference between what it pays for the oil and the price the market sets for the finished product – a margin that historically has hovered around 25 cents a gallon. The 25 cents a gallon margin gets compressed when demand falls, or when more supply enters the market. The margin is also reduced when refiners must invest in regulatory and environmental compliance costs not incurred by our international competitors.

To give you an idea, Valero has reinvested approximately **$8.2 billion** to enhance and upgrade our refineries in the past three years. Since 1997, we have re-invested **$3.5 billion** on regulatory and environmental compliance. To comply with regulatory and fuel specifications, we expect to spend another **$1.4 billion** through the end of 2010. Given the significant reinvestment required to comply with additional requirements enacted each year, Congress and the Administration must consider and mitigate the impact on not only supply and cost, but on the domestic refining industry's ability to remain viable, much less profitable.

There is an assumption that because importers of refined products would also have to purchase carbon emission allowances, the rising production costs faced by U.S. refiners could be absorbed by the cost increases at refinery plants. However, according to the Energy Policy Research Foundation, the large volume of low-cost refining capacity worldwide, rising legacy environmental and biofuels costs, corporate tax policies, and demand reductions from rising fuel prices would further reduce U.S. operating capacity by an additional 2 million barrels per day. Direct and indirect employment losses would range from 40,000 to 350,000 American workers across the forecast period.

Refiners Support the Creation of American Jobs

So with all of the choices before you, it is important to spell out what America's domestic refining industry *does* support. First, we support the creation and retention of sustainable and well-paying American jobs. My company, Valero, was ranked No. 10 on *Fortune* magazine's list of the "100 Best Companies to Work For" in America in 2008. Every day, Valero's thousands of dedicated employees contribute individually to the quality and reliability goals that are at the core of our corporate philosophy. Our employees, many of whom are union members, are our most important and best asset. They also provide immense value to each of their communities through tremendous volunteer service – nearly 150,000 hours in 2008 alone.

The adverse impact of cap-and-trade legislation on these workers will be staggering. Valero refinery employees live in your state Senator Boxer and Senator Inhofe, and in the states of other members of the Committee from Delaware, New Jersey, Tennessee and Louisiana. These are real people, many who did not graduate from college, but instead learned a critical trade, and work hard every day. These workers have good health care benefits and are able to save for retirement. These workers have the opportunity to raise a family, buy a home, take a vacation, send their kids to college, and live the American dream.

Keep these workers in mind as you consider cap-and-trade legislation. As the Congressional Budget Office (CBO) stated in its September 2009 report, cap-and-trade legislation such as H.R. 2454 will "reduce economic activity through a number of different channels."[2] Two weeks ago, before the Senate Energy and Natural Resources Committee, CBO Director Douglas Elmendorf expanded on this point, specifically regarding the refining and petrochemical sector, stating, "[t]he industries that produce carbon-based energy — coal mining, oil and gas extraction, and petroleum refining — would probably suffer significant employment losses over time . . . Among (energy intensive) industries, employment losses in chemicals and transportation services could be relatively

[2] Congressional Budget Office, *The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions*, September 2009, p. 12

large." Mr. Elmendorf also stated that displaced workers will not likely find new jobs quickly, and that "[t]he fact that jobs turn up somewhere else for some people does not mean that there aren't substantial costs borne by people, communities (and) firms in affected industries and affected areas."[3] Other analyses have shown that significant job loss will occur as a result of cap-and-trade legislation. One examination of H.R. 2454 projects job losses of 1.8 million to 2.4 million.[4]

Projected job losses and adverse economic consequences have been too readily dismissed throughout the climate change legislative debate. Amid concerns over a jobless recovery, we can hardly afford to dismiss the potential economic harm of pending cap-and-trade legislation. The concept of "green jobs" has been promoted as an employment safety net to assist those workers who will lose their jobs. But we must question whether the quantity and quality of these jobs is enough to replace existing jobs that will be lost under proposals like H.R. 2454. Policymakers also must consider whether it is fair to ask a 15- or 20-year refining veteran with a strong career track to seek re-training in another sector that may not offer comparable salaries and benefits – a path that would clearly impact his or her lifestyle and that of his or her family.

Lawmakers also must look cautiously at policies trying to engineer job replacement. One study examining Spain's attempt to create "green jobs" has found that at least 2.2 other jobs were lost for every "green job" created. That study projects that if the United States attempted to follow Spain's lead, 6.6 to 11 million American jobs would be lost.[5]

Let me be clear: I am not suggesting that NPRA or Valero is opposed to the creation of "green" or any other jobs. On the contrary, with national unemployment nearing 10 percent, we simply want policymakers to first preserve existing jobs and then look for ways to create new opportunities for the American work force.

[3] Douglas W. Elmendorf, Testimony, United States Senate Committee on Energy and Natural Resources, October 14, 2009
[4] National Association of Manufacturers/American Council for Capital Formation, *Economic Impact of the Waxman-Markey American Clean Energy and Security Act*, August 12, 2009
[5] Gabriel Calzada Álvarez Ph.D., "Study of the Effects on Employment of Public Aid to Renewable Energy Sources," Universidad Rey Juan Carlos, March 2009

Refiners Support Consumers' Fuel Choices, Reliability and Affordability

Let me turn to what this all means for the American consumer. To put it bluntly, what is bad for business is bad for the consumer. Cap-and-trade legislation will ultimately impose large, new costs on any user of gasoline and diesel – from individual motorists and families to farmers, businesses and truckers. Driving in the United States is not seen as a luxury or a privilege. To the average American, it is a necessity, and a truly integral part of our economy.

Consumers deserve a broad and diverse menu of safe and reliable fuels. Today, Americans can take advantage of a diverse array of fuels to power vehicles for personal, business or recreational use. Today's vehicles operate primarily on traditional and proven gasoline and diesel, while emerging technologies such as smaller, more efficient batteries for hybrids and advanced forms of biofuels are still years, if not decades, away from commercial viability and affordability for the average American.

Refiners Support Enhanced Energy Security

One of our chief concerns with S. 1733 and its House companion, H.R. 2454, is the distinct competitive advantage both bills provide foreign refiners and producers, which, in many cases, are state-owned entities. The percentage of refined product imports in our nation's fuel supply has consistently increased over the past decade, rising from two percent of the market in the year 2000 to more than 10 percent in recent years.[6] An August 24, 2009 UPI article shows the extent of foreign refiners' plans for our markets and needs:

> Asia has been importing refined oil products like gasoline and diesel from the West for decades to keep the wheels of its economies rolling. But the tables may be turning as the region's two largest economies, India and China, aggressively pursue capabilities to refine imported crude on their own, not only for local use but also for export. Experts say that India and China could provide intense competition on the global market to refineries in North America and Europe, which could suffer losses and eventually close down.[7]

[6] Energy Policy Research Foundation (EPRINC), *Do Higher Oil and Gas Taxes Pose a Threat to U.S. Energy Security?*, August 4, 2009, p. 22
[7] Indrajit Basu, "Asian oil exports threaten U.S. refineries," UPI, August 24, 2009

India, China and Europe are moving quickly to target our markets. According to a May 18, 2009 Bloomberg story:

> "Europe will export to the U.S. as much gasoline as the U.S. will take," said Andrew Reed, an analyst with Energy Security Analysis Inc. in Wakefield, Massachusetts. ... "Regardless of price, they will be looking to unload in the U.S." ... India's Reliance Industries Ltd. in December started a 580,000-barrel-a-day refinery in Jamnagar, with plans to export gasoline to the U.S.[8]

China and India are already poised for an economic attack on the U.S. economy. As another recent article states:

> The financial crisis has left [the United States] hobbled with significant government and household debts and sharply reduced prospects for growth. Developing nations such as China, Brazil and India, on the other hand, have weathered the economic storm significantly better. So while this latest proposal [to move away from the dollar] is born of financial calculation, it is also a reflection of a new economic world order.[9]

"[A] new economic world order." That is a rather ominous forecast for American consumers and businesses. The United States' refining and petrochemical industries already face significant competition in global markets – *without the adverse effects of cap-and-trade climate change legislation*. Such policy would only increase our reliance on foreign products. One recent study concluded that H.R. 2454 would *reduce U.S. refining throughput by up to 4.4 million barrels per day*. The same analysis found that annual U.S. refining investments would decrease by up to $89.7 billion (an 88 percent decline in investment), *causing petroleum product imports to more than double from nearly 10 percent in the baseline case to close to 20 percent under cap-and-trade legislation.*[10]

Certain special interest groups tie climate change to the issue of national security in an attempt to bolster support from untapped voters. Realistically, though, given the negative effect cap-and-trade legislation would have on domestic energy production and on our ability to compete globally, this alleged solution for enhanced national security is actually one of its gravest threats.

[8] Barbara Powell and Aaron Clark, "Gasoline Ending Biggest Rally in Decade as Driving Season Opens," Bloomberg, May 18, 2009
[9] Editorial, "The end of the dollar spells the rise of a new order," *The Independent*, October 6, 2009
[10] American Petroleum Institute, *Waxman-Markey (H.R. 2454) Refining Sector Impact Assessment*, August 24, 2009

Our national security would not benefit from increased imports of refined fuels. Our national security would not benefit from the Pentagon's reliance on military fuels produced in unstable regions of the world. More importantly, our national security would not benefit from the "new economic world order" that this legislation could bring. War can take many forms. While a world war, thankfully, does not appear to be imminent, economic warfare continues to be a significant threat -- one that should constantly be considered.

Refiners Support Realistic Policies That Preserve Our Competitiveness While Reducing Emissions

To ensure a secure, safe and reliable fuel supply for consumers, U.S. refiners strongly support a robust, balanced and realistic energy policy rooted in true fuel diversity. A realistic energy policy -- one that would truly benefit consumers and enhance energy security -- would not exclude fuels that are proven, reliable, secure, and are available today in commercial quantities. Given the global energy outlook and an ever-increasing population, debilitating the use of fossil fuels is hardly realistic. We must continue to invest in future energy technologies. But those investments must not happen at the expense of today's proven and commercially viable technologies. A realistic *environmental* policy should work in harmony with, not against, such an energy policy.

We believe that greenhouse gas (GHG) emission reduction programs should include meaningful global participation, recognizing the imbalances among national programs and global enforcement efforts. The programs should also ensure that the U.S. can continue to compete in global markets, particularly with regard to fuels, petrochemicals and other petroleum-based products. We also believe that carbon control program requirements and their timing should co-exist with statutory and regulatory requirements that increase GHG emissions from domestic industrial operations. In addition, a national GHG reduction program should preempt all state, regional, and local programs, as well as existing federal statutes such as the Clean Air Act, Endangered Species Act, or any other federal program. Finally, we believe a national program should provide realistic emission-reduction targets that integrate diverse supplies of long-term energy sources and technologies, and should apply to as much of the U.S. economy as possible, without political preconceptions or exemptions.

Collectively, these concepts would create a far more realistic approach to reducing GHG emissions while increasing and preserving our nation's ability to compete in the global marketplace.

Conclusion

Madam Chair, your colleague from North Dakota, Senator Dorgan, described Congress' immediate challenge best when he said earlier this month, "I think standing in a deep economic hole is a difficult time to do big policy things that cause uncertainty."[11] S. 1733 and H.R. 2454, if enacted, would create even greater uncertainty for investment, employment and our nation's economic health. What Congress and the Administration do today and in the near future will impact investment in projects that could require 10 to 15 years to complete. The success of the businesses we represent, the livelihoods of our employees, and the success of our nation's economy depends on sound policy that advances, not inhibits, a reliable, affordable supply of energy in the domestic marketplace. As the discussion of climate change legislation and regulation progresses, Valero and NPRA and its members are ready to work with you to create a policy that will protect the interests of the American consumer, preserve the jobs of our employees, enhance U.S. competitiveness globally, and achieve our shared environmental objectives.

Thank you for your attention to our perspective. I am pleased to answer any questions that you may have about my testimony.

[11] Richard Cowan, "U.S. economy could worsen climate bill prospects," Reuters, October 6, 2009

Post Hearing Questions

Senate Environment & Public Works Committee

Hearing on "Clean Energy Jobs and American Power Act"

October 29, 2009

Questions for Bill Klesse:

Questions from:

Senator Amy Klobuchar

1. In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy - from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?

Both Valero and the National Petrochemical and Refiners Association (NPRA) support the development of all types of energy, including renewables. We need a diverse, efficient and reliable supply of energy in this country, and we need to embrace all possible options, including renewable energy, nuclear energy and increased production of conventional and unconventional petroleum fuels. We are concerned, however, that this bill does not provide "private sector market certainty" for these energy projects. Several studies with varying degrees of cost projections highlight the lack of uncertainty in the carbon market this bill looks to create. Both H.R. 2454 and the Kerry-Boxer climate draft only serve to make conventional energy, such as coal and gasoline, so much more costly that other alternative technologies begin to look less costly. In doing so, the bill is only likely to lead to more expensive energy for everyone. More importantly, given its potential to raise costs too high too fast, the bill has the potential to send our economy into an even deeper recession, threatening the generation of capital needed to invest in research and development initiatives for new energy technologies. In effect, this bill would create winners and losers, and we are opposed to public policy that produces such results.

In addition, government estimates indicate existing and proposed regulatory programs will lead to significant GHG emissions reductions from the transportation sector. These regulations include enhanced CAFÉ standards and a significantly expanded Renewable Fuels Standard (RFS), both mandated by the

Energy Independence and Security Act of 2007. Many of our businesses have also invested significantly in alternative fuel technologies, without any sort of a cap and trade program. As mentioned in both our written and oral testimony, Valero owns a 50 mega-Watt wind farm in Texas and recent investments have made Valero one of our nation's largest ethanol producers.

Senator James M. Inhofe

1. The current allowance allocation system provides a total of 2.25% free allowances for the refining sector, than subdivides this allotment into separate pools for integrated, midsize and small refiners. Small refiners receive a full 1 % - almost half the total pool - midsize receive .5%, and all others receive .75%. Since the purpose of these free allowances is to mitigate consumer costs, can you tell me what percentage of our fuels mix is produced by each of these subsectors, and whether this discriminatory allocation system actually helps consumers or is merely another example of this bill picking winners and losers? Why are we penalizing the refiners that produce most of the fuel used by consumers in this country?

NPRA is not able to provide the data requested in the first part of this question due to the complex subdivisions outlined in S. 1733 and the Committee's very short deadline for replying to these questions. We will research these figures and forward them to the Committee in the near future.

With respect to the second part of this question, the proposed subdividing of the refiner allowances under this bill will do virtually nothing to help consumers, truckers and farmers, reduce the refining industry's cost of compliance with the bill, or mitigate the substantial job losses this bill will cause in our industry. Moreover, small refiners which are typically isolated geographically are not equipped to produce the incremental fuels needed to replace idled refineries. Theoretically, even if they added fuel capacity the pipeline, trucking, rail, and other infrastructure is not in place to transport their product to market. S.1733 is worse than Waxman-Markey because it picks winners and losers within the refining industry. It is the equivalent of putting a band-aid on a severed limb and trusting that the patient will survive.

2. Mr. Klesse, the bill before us authorizes 2.25 percent of distributed allowances to be given to the refining sector. In total, these allowances will be worth a significant amount of money. Why isn't this amount sufficient to address the cost impacts refiners are likely to face as they transition into compliance with the cap?

The legislation's allowance allocation for the refining sector will come nowhere close to covering the compliance obligations domestic refiners face under this bill. Under this bill, refiners are responsible for securing allowances for both stationary source emissions from their production facilities as well as the emissions from their fuel products after they reach the consumer. These two categories together come to approximately 44 percent of domestic greenhouse gas emissions covered in the legislation. So while refiners would receive 2.25 percent of emissions allowances, our industry is required to purchase allowances equivalent to 44 percent of total emissions covered in the bill. As I stated in my testimony before the Committee, this will have staggering impacts on domestic refiners, our customers and our employees. In addition, refiners have no control over consumer emissions, so assigning those emissions to our industry is neither fair nor addressed by the bill's allowance allocation. As an example, industry wide we estimate the compliance cost for process emissions, with carbon at $20 a ton, to be $4.1 billion a year and the cost of product emissions to be $63 billion.

3. You say allowances needed to cover consumer emissions will be a great expense for the industry that is not addressed by the allowances the bill will distribute to you. Why not just pass those allowance costs on to the consumer in the former of higher prices?

While I can't discuss Valero's specific pricing considerations for legal reasons, I can give you a general answer. First, all refiners work in an international marketplace and sell a commodity product. Small changes in our price structure can yield substantial market penetration for imports of refined product. Even if gasoline imports will bear some charge for consumer emissions, we believe distributed allowances are insufficient to fully address our process and secondary energy (electricity) costs. The combined impact on independent refiners would leave us vulnerable to imports and would undermine the domestic refining base and energy security.

It is axiomatic under standard economic theory that only two market conditions would lead to full pass through of regulatory compliance costs: (1) "perfectly inelastic demand;" or, (2) "perfectly elastic supply." Perfectly inelastic demand means that consumers will buy the product no matter what it costs. Perfectly elastic supply means that producers can supply any amount of their product at the same marginal costs. *Neither situation is true for the U.S. refining industry.* This reality, along with the anticipated added costs associated with stationary source regulations, the unequal allocation scheme, and limiting the availability of international offsets highlight why the allowances allocated fall short.

As costs increase, consumers consume less or buy more fuel efficient vehicles, leading to decreases in demand. Historically, consumer prices have decreased with consumer demand, limiting the ability for businesses to pass through additional costs. An illustration of this fact is the summer of 2008, when oil prices soared to over $140 per barrel, consumer demand rapidly decreased and refiners lost money due to the inability to pass along such costs. The legislation before the Committee looks to create a permanent state of declining demand. Recently enacted regulations (e.g. CAFÉ and the RFS) will also greatly reduce the demand for petroleum products in this country. Given this situation, refiners are not in a position to absorb the exorbitant new costs of the cap and trade bill before the Committee.

4. The bill will also contain an international reserve program that in essence places a border adjustment on fuels coming in from countries that refine gasoline. Why wouldn't that address your problem?

Valero and NPRA are closely examining that program. Valero has long supported adjustments to reflect the different environmental regulations our competitors in other countries face or in some cases do not face. However, we have several problems with the current proposal. First, we have found that even if other countries have similar laws on the books, they have very different approaches to monitoring and enforcement. In particular, the US is one of the few nations to allow the liberal use of citizen suits in its environmental programs. We fear that the bill's scrutiny of international efforts will not pick up these crucial differences. Second, we are concerned that the program might be held to violate World Trade Organization obligations. If it were found in violation, we are not sure the federal government would have the political will to implement the program. Third, the bill will require domestic refiners to buy allowances for both process and consumer emissions. Importers of foreign products may have to buy allowances for consumer emissions, but they will not be forced to buy allowances for process emissions. Foreign refiners won't have to pay for any allowances. Given this situation, the bill could create an insurmountable competitive advantage for foreign refined products. And last, the cap's implementation comes before the international program is established – potentially letting the horse out of the barn before the door is closed.

5. We have heard proposals that would designate a certain portion of refiner distributed allowances to be held for so-called small refiners. Do you have any opinion on that?

NPRA opposes any designated small refiner allowance share. To be sure, small refiners can and should apply for general refiner allowances and they should be assigned whatever they merit based on throughput or other fair distribution formulas. Holding some allowances specifically for a particular subset of the industry is bad energy and environmental policy. Further, it makes little sense to protect workers at identically-sized refineries just depending on their ownership. A small refinery owned by a larger company may also be the marginal operator in that company's fleet and may also serve a more isolated area. Diverting credits from facilities like that places them at risk for no compelling reason.

6. Allowance prices in general are moderated by our strategic reserve policy. This means that if the auction price gets too high, Valero would have the option of participating in a special auction of reserved allowances. Why isn't that sufficient to contain costs for your company?

Valero and NPRA believe that the strategic reserve will be insufficient. First, it does not represent a ceiling on the top price for allowances. Therefore, it does not ensure predictability for planning purposes. Second, the reserve itself is filled by taking some near-term allowances off the market and placing them in reserve. If the reserve runs out, it is filled in the same way. We believe this will place the government in competition with industry for scarce allowances, potentially making the problem worse. Third, EPA's own cost analysis found that while reserve mechanisms are designed "to contain price volatility, control costs, or both," the Agency "has not assessed their ability to accomplish these stated goals."[1] The EPA even admits that refilling the strategic reserve can result in higher allowance prices if the government is bidding against the regulated community for needed allowances or offsets.[2]

7. Why can't Valero just buy offsets? The bill allows for the purchase of some two billion tons worth of offsets, allowing both domestic and international options.

Again, Valero and NPRA do not believe that offsets provide sufficient certainty for adequate cost containment. It is unclear how many domestic or international offsets will actually materialize. We know that major environmental organizations have indicated their opposition to offsets. And yet, neither the House nor the Senate bill limits the ability of environmental organizations to tie up the approval of offsets in administrative and legal delays. EPA candidly admits that it relies on offset literature that has "not attempted to model specific eligibility or administrative issues,"[3] despite the enhanced scrutiny of both bills of offsets.

If the EPA has guessed wrong on offsets, the results can be dire. Instead of the relatively rosy picture of offsets assumed by EPA, researchers at MIT assumed what was termed a "medium case" for offsets. Rather than assuming quick availability of offsets, MIT assumed that offset availability would ramp up from zero in 2012 to the full two billion by 2050. The medium assumption case "was 193 percent higher than the allowance price in the full offset case." Finally, if the previously mentioned concerns did not exist, the volume of available offsets would not be sufficient to cover refinery consumer emissions obligations under the legislation.

8. While the current bill does not contain a low-carbon fuel standard, past proposals certainly have. Some Senators support these proposals. Does Valero have a view on them?

Valero and NPRA oppose a low-carbon fuel standard. First, our refineries are still implementing two phases of reformulated gasoline programs at great expense in money and time. An LCFS would complicate existing law. Second, if refineries themselves are placed under a carbon cap due to this legislation, an LCFS would equate to double accounting for carbon. Third, an LCFS mandate would be inherently inflexible and extremely costly. Fourth, an LCFS endangers energy security. If the standard is used to discourage new sources of supply – particularly oil sands from Canada – it would ironically make us more dependent on the Middle East instead of North American sources of supply.

Senator George V. Voinovich

1. Mr. Bill Klesse (CEO Valero Energy Corporation) - I have long been concerned by our nation's dependence on foreign sources of oil. This concern led me to introduce the National Energy Security Act, a comprehensive bipartisan plan to wean our nation off of its dependence on foreign oil. It would expand our energy resources by opening up the most promising areas of the Eastern Gulf of Mexico and providing $50 billion in federal loan guarantee authority for low-carbon electricity, including from nuclear and advanced coal. The bill would also reduce our oil usage by promoting the electrification of our light-duty transportation fleet. I was happy to see a number of the bill's provisions-especially the supply title that opens up the Eastern Gulf -- included in the American Clean Energy Leadership Act that was marked up after six months of debate in the Senate Energy and Natural Resources Committee. While it will not be a panacea, I do believe tbat, should the senate energy bill pass and the provision to expand oil production be included, that it will go a long way towards making our country more energy secure. I am concerned, however, by Waxman-Markey and the way it deals with refineries. You outlined pretty clearly in your statement how refiners, who are already suffering under this recession, would need to further reduce operations to meet emissions reduction targets. With less refining capacity in the U.S., we would be importing less crude oil, but we would need to import increasing levels of refined petroleum products to make up for our lost refining capacity. A new study by EnSys says that under Waxman-Markey our dependence on foreign imports of refined petroleum products would double by 2030 - from 10 percent today to 20 percent in 2030. Mr. Klesse, in your opinion, are we more or less energy-secure if we are shifting energy imports from crude oil to refined products?

> I believe our security is best served by having a vibrant domestic energy production sector that has reliable access to supplies so it can produce a diverse array of affordable fuels. I do believe this legislation would lead to less domestically produced refined petroleum products and more foreign refined petroleum product imports. What does this mean for our military? It may be that the military will have a harder time finding jet fuel for our fighter planes or fuel for our naval fleet. Fuel may no longer be available near military bases and therefore more susceptible to supply disruptions. I do not believe such a scenario would be beneficial from an energy security perspective.

2. Mr. Klesse - Thank you for your testimony and for being here today. In your testimony you state that if this bill were to be enacted, and carbon was $20 per ton, your direct emissions liability could be nearly $230 million for your three facilities - and your indirect emissions liability through your customers' fuel usage could be nearly $6 billion per year. Given the complexities of this bill, could you explain to us a bit more about how your company is expected to cover these large costs. Will the

2% of the total allowances given to refiners help you meet these increased costs? In your opinion what is the optimal amount of allowances that refiners should receive?

As I stated before, the 2.25% of allowances will not be anywhere near enough to help refiners meet the increased costs imposed by this legislation. Refiners are held responsible for approximately 44 percent of the greenhouse gas emissions regulated in the legislation, yet we are allocated a small fraction of what we need to cover this liability. As for how our company is expected to cover these large costs—I do not know. I know of very few companies anywhere that would be able to absorb substantial and volatile new costs without damage to their viability and long-term health.

As for the optimal amount of allowances refiners should receive – Valero and NPRA are not going to offer a specific number. We will say that the allowances granted refiners should fairly and adequately reflect the compliance obligations imposed on refiners. The allotment system proposed under this bill is punitive and deeply flawed, and we do not feel Congress can adjust the allowance allocations in a way that would mitigate the devastating impacts of this legislation on domestic refiners.

3. Mr. Klesse - You alluded to this in your testimony, but one of the reasons the authors of this bill provide for having only allotted refiners 2% of the allowances - is that they believe refiners can pass 100% of their costs of compliance onto consumers at the pump. I believe this in an important myth to dispel - so could you please discuss in greater detail why this is simply not the case. If we wanted consumers to use less gasoline, what do you believe would be a more sensible approach?

Historically, there has been no such thing as 100 percent cost pass through in the refining sector. Like any other sector, we are driven by the elasticity of supply and demand, and we do not have the ability to pass through all of our costs onto the consumer. Please see my previous answer to Mr. Inhofe's question on pass through for more detail. It is likely that some amount of cost will be passed through and consumers will experience this in the former of higher fuel costs – costs that several studies indicate could be significant. Refiners will have to absorb the costs that cannot be passed through. As previously stated, I do not believe refiners will be able to absorb the tremendous costs imposed by this legislation.

As for consumers using less gasoline, I urge Congress to examine the impacts of recently enacted legislation, namely the Energy Independence and Security Act of 2007. New CAFÉ standards and a drastically expanded Renewable Fuels Standard (RFS) will significantly reduce consumer demand. Several analysts have predicted that U.S. gasoline consumption has already peaked for the long run.

Senator Lamar Alexander

1. A new study by EnSys says that under Waxman-Markey our imports of refined petroleum products would double - instead of being 10% in year 2030 our fuel imports would be 20%.

> **1. Would doubling the reliance on foreign sources of fuels increase market volatility?**
>
> For legal reasons Valero and NPRA will not make predictions about future market behavior. We can say that an increased reliance of foreign sources of fuel will lead to fewer American jobs and raise energy security questions.
>
> **2. Are we more or less energy-secure if we are shifting energy imports from crude oil to refined products?**
>
> Valero and NPRA are certain that our security is best served by having a vibrant domestic energy production sector that has reliable access to supplies so it can produce a diverse array of affordable fuels. This legislation would lead to less domestically produced refined petroleum products and more foreign refined petroleum product imports. I do not believe such a scenario would be beneficial for our nation from an energy security perspective.

2. We in Tennessee are proud that Valero employs 600 Tennesseans, including contractors, at its refinery in Memphis. The facility is a major refinery of fuels, including jet fuel used at the Memphis airport and FedEx.

> **1. What would the cost of the Kerry-Boxer Bill be for the Memphis facility?**
>
> **2. How would the Memphis facility comply with the Kerry-Boxer bill if it were to become law? Buy credits? Can't you just pass on the cost of this to the consumer?**
>
> **3. What would the practical effect on employees, contractors, state taxes, etc. of the Kerry-Boxer bill be?**

Answer to Questions 1-3:

> The Memphis Refinery obligation under S.1773 is more than $550 million per year in compliance costs. This includes both the process emissions and mobile source emissions. As you noted, the Memphis Refinery produces the transportation fuels needed for Memphis, Western Tennessee and many communities on both sides of the Mississippi River. This refinery competes with

much larger, more complex facilities along the Gulf Coast and its advantage is location and good workers. The impact of S. 1773 on the Memphis Refinery is unclear but we welcome the opportunity to visit you more about the impact if this legislation moves forward. The Memphis Refinery does so much in the community through countless charitable events and the contribution to local and state governments is substantial. For example, in 2008 Valero Memphis paid $2 million in property taxes, nearly $3 million in sales tax, and close to $2.5 million in payroll and other employee related taxes.

[1] EPA, "Economic Impacts of S. 1733: The Clean Energy Jobs and American Power Act of 2009," p. 10.

[2] Ibid, p. 12-13.

[3] Ibid., p. 8

Senator BOXER. Thank you very much, sir.

Mr. Vassey. And let me say, Brett A. Vassey, President and CEO, Virginia Manufacturers Association.

Welcome.

STATEMENT OF BRETT A. VASSEY, PRESIDENT AND CHIEF EXECUTIVE OFFICER, VIRGINIA MANUFACTURERS ASSOCIATION

Mr. VASSEY. Thank you, Chairman Boxer, Senator Inhofe and members of the committee for the opportunity to testify before you today on this bill.

I am the President and CEO of the VMA from Richmond, Virginia. We are the trade association for manufacturers and industrial suppliers to manufacturers for 87 years. Our members employ over 120,000 Virginians. We produce over 400 megawatts of renewable energy from our facilities, and finally, we make everything from ships to chips. That is our logo.

We are also very proud we are from the Commonwealth, the fourth year running the No. 1 State for business as ranked by Forbes Magazine.

So, there is additional information in the testimony I submitted on the economic impact, and I will, in the interest of time, just get to the points.

My testimony today is going to be specifically addressing the cap and trade provisions of this bill. Due to the time constraints, I am only going to address three of the four issues. In my written testimony, those issues are going to be specific to the credit allocation, to the issue we are bringing forward of capacity confiscation, and to, finally, leakage, which is addressed only in part in this bill.

On the credit allocation, this system allows political leaders to choose winners and losers in the economy. The important thing about this is the system risks global manufacturing because they make decisions on future capital investments today. Congress and the EPA allocating credits is a critical decision before you because States like Virginia and other States will lose opportunities to compete and create jobs in the future as long as this is a threat hanging over the heads of those looking 3 to 5 years where they are going to invest. I will explain in just a moment why that is linked to leakage.

But the second issue is productive capacity confiscation, and this is important for us. To avoid paying for emissions credits, only point sources such as manufacturers that comprise only 3 percent of all businesses in the Commonwealth, mind you, will be forced to involuntarily accept limits on their emissions. This limitation ignores the fact that Virginia's industrial sector emits less CO_2 today that it did in 1990.

Additionally, in accepting lower allowable emission rates, the companies involved will be restricting each of their regulated facilities to a correspondingly lower allowable production rate. Energy equals production. This is productive capacity confiscation, and there is no provision in this bill to compensate Virginia's, or any State's, affected businesses for the productive capacity that the Federal Government will be confiscating from us.

Now, on to leakage. The truth is cap and trade, from our perspective, is simply a tax on energy, and it is regressive on manufacturing because of its intense nature. There is nothing in this bill that stops leakage to more favorable nations, and there will be more favorable nations.

Virginia, for instance, if we eliminated all CO_2 emissions from all sources, China's growth alone would replace it in 77 days. On this note, it is my opinion, which I would like to share with the committee, that there is a gentleman named Mr. Tom Mullikin, he is environmental attorney with Moore & Van Allen out of Charlotte, North Carolina, who has produced a very substantial body of work on this issue and has changed the thinking of many global leaders on the impact of leakage. And I suggest that he could be somebody very helpful to you.

Mullikin's findings, basically, his finding is basically that due to productivity of American manufacturers and their workers and the efficiency of our facilities, our Nation's carbon emissions from industry are only 11.5 percent of the country's overall carbon emissions whereas the EU's is 16.2, Japan's is 21.5 and China's is 28.

In other words, the U.S. is the largest manufacturing economy in the world, and if it were to grow the industrial base rather than limit it, we may grow GHG emissions slightly in this country, but we would lower the overall global emissions to the world.

And to give you evidence of that, since 1997, Virginia manufacturers have increased its gross State product—excuse me, since 1997, the Virginia industrial sector has increased its gross State product per kilowatt hour of electrical input from $2 to $3.14. What that means is we are 64 percent more efficient in production that we were just in 1997. And I would dare say if you challenge your State, you will find the same data.

Industrial businesses understand the importance of environmental stewardship, voluntarily spending millions. In Virginia, we spend nearly $1.72 billion just in compliance costs on environmental regulations. We commend the efforts of this body to legitimately address this complex scientific issue while affording equal protections to the economy. These are not mutually exclusive principles.

You already know the studies published by NAM, the Heritage Foundation and others which I will not recite. But in your materials you do have a letter dated June 6, 2008, from 10 Senators of this body signed also by our Senator, Jim Webb, stating that there must be protections for manufacturing jobs in the then Lieberman-Warner bill. But the most important statement they made is this bill must include enhanced safeguards to ensure a truly equitable and effective global effort that minimizes harm to the U.S. economy and protects American jobs. We agree.

In closing, the VMA wants Congress to develop responsible policies that protect domestic jobs and the environment. We are concerned that these bills will cap industrial competitiveness and trade domestic manufacturing jobs abroad for entirely undefined environmental benefit. We can do better, and we must do better.

Thank you for the opportunity.

[The prepared statement of Mr. Vassey follows:]

Testimony of Brett A. Vassey, President & CEO, Virginia Manufacturers Association

Legislative Hearing on S. 1733, Clean Energy Jobs and American Power Act

US Senate Committee on Environment and Public Works
9:30 a.m., October 28, 2009
Room 406, Dirksen Senate Office Building

Chairman Boxer, Senator Inhofe and members of the Senate Committee on Environment and Public Works, thank you for the opportunity to testify on S. 1733 – the Clean Energy Jobs and American Power Act.

I am the President & CEO of the Virginia Manufacturers Association. We have been the state trade association for manufacturers and industrial suppliers to manufacturers for 87 years in the Commonwealth of Virginia. Our members employ over 120,000 Virginians in all 19 manufacturing industries across Virginia – our members make everything from ships to chips.

Based on the last economic impact report[1] conducted by our state's economic development agency, the Virginia Economic Development Partnership, Virginia's manufacturing sector supports:

- 1,015,971 jobs
  - 303,829 direct jobs
  - 712,142 additional jobs
  - Direct and indirect jobs equate to 27% of total employment in Virginia
- $172.0 billion in annual economic output

[1] http://www.vamanufacturers.com/docs/publications/MfgImpactEconDriversPlan.pdf

- $85.8 billion direct output
- $86.2 billion additional output
- Direct and additional output equate to 49% of Virginia's Gross State Product

Further, Virginia's manufacturing sector, its supporting industries, and its employees generate:

- $6.3 billion in tax revenue
  - $3.5 billion in state tax revenue, including sales and income taxes
  - $2.8 billion in local tax revenue
- $2.4 billion in property taxes
- $400 million in sales taxes

My testimony today will specifically address the "cap and trade" provision of S. 1733 and the American Clean Energy and Security Act of 2009 (H.R. 2454). I will speak to four issues pertaining to "cap and trade" that are not regularly addressed in the context of climate change legislation. The four areas are as follows:

1. Federal Government Credit Allocation. This system allows elected political leaders to choose "winners and losers" in the economy. Waxman-Markey directs that every commercial user of energy would be given a certain number of carbon credits, permitting it to emit a specific amount of carbon each year. If a manufacturer exceeds its credits, it has to purchase extra credits from others who do not reach their cap. This system has too much risk for global manufacturers who are making decisions about their future capital investments today. Congress allocating credits is a critical decision because Virginia and

other states will lose opportunities to compete and create jobs in the future as long as the threat of this allocation system exists in the public debate.

2. Productive Capacity Confiscation. To avoid paying for emissions credits, only point sources such as manufacturers, that comprise only 3% of Virginia's total businesses, must involuntarily accept limits on their emissions. This limitation ignores the fact that Virginia's industrial sector emits less CO_2 today than it did in 1990 (see Appendix B). Additionally, in accepting lower allowable emission rates, the company will also be restricting each regulated facility to a correspondingly lower allowable production rate. This is productive capacity confiscation and there is no provision to compensate Virginia's affected businesses for the productive capacity confiscated by the government.
3. Leakage. Proponents of "cap & trade" believe immediate regulation will force industry to stop using traditional sources of energy. Unfortunately, this position demonstrates a fundamental misunderstanding of global manufacturing today. The truth is "cap & trade" is just another tax on businesses and consumers - regressively so on manufacturing - and it does nothing to stop "leakage" to nations with more favorable conditions. For example, even if Virginia limited all of its CO_2 emissions, China's CO_2 emissions growth alone would replace all of Virginia's CO_2 emissions in only 77 days. Virginia is .44% of the global GHG emissions.
    a. It is my opinion that Mr. Tom Mullikin, a senior environmental attorney with Moore & Van Allen in Charlotte, NC, is one of the most persuasive and well cited researchers in this policy area and should be invited to speak to this Committee. His documentary, *Climate Change: Global Problems, Global Solutions*, has had the most profound impact on industrial leaders across the US about how to look

differently at the political and economic solutions to climate change. For example, American manufacturers are three times more productive than Asian competitors and 33% of China's CO_2 emissions are from the production of goods for export. In essence, one of Mullikin's findings is that due to the productivity of the American manufacturer (and worker) and the efficiency of US manufacturing, our nation's carbon emissions from industry are only 11.5% of the country's overall carbon emissions, whereas, the EU's industrial equivalent is 16.2%, Japan's is 21.5% and China's is 28% (Source – World Resources Institute). In other words, the US is the largest manufacturing economy in the world and if it were to grow that industrial base, rather than limit it, we may grow GHG emissions domestically by a small percentage, but we could lower the overall global GHG emissions.

b. These facts should embolden the Senate to explore the role of global industrial competition as a motivating factor for other countries.

c. Due to the global market implications of this legislation, it is also recommended that the Senate also explore the climate modeling by NASA (GISS) as it relates to challenges accurately predicting surface temperatures over the past decade, heat content of the ocean and the temperature of the atmosphere.

4. Market Interference. The U.S. manufacturing industry relies substantially on natural gas as a feedstock, for process requirements and for electric power, and traditional energy resources such as coal, nuclear, oil and biomass. The National Association of Manufacturers largely attributes the shutdown of businesses and loss of 3.7 million premium wage U.S. manufacturing Jobs from 2000 to 2008 to the quadrupling of natural

> gas prices. This was driven by construction of over 100,000 megawatts of new natural gas based power plants early this decade. It was based on conclusions that production of US natural gas would increase substantially and that prices would remain low for a very lengthy period. Neither of these occurred. Given the language in section 181 of S. 1733 this quick build out of new natural gas plants could occur again and bring another substantial loss of U.S. manufacturing jobs. Further, cap and trade's effect of limiting traditional fuel sources will not serve to encourage energy independence for the U.S. because it ignores the technology challenges of carbon sequestration, affordability and reliability of wind and solar energy, biomass competition with food and forest products industries and the proven reserves of fossil fuels in the United States that exceed all other countries (see Appendix A).

Industrial businesses understand the importance of environmental stewardship, voluntarily spending millions on this effort each year. According to a Virginia Joint Legislative Audit & Review Commission (JLARC) report[2], Virginia manufacturers already spend between $606 million and $1.72 billion per year on environmental compliance. Therefore, we commend the efforts of this body to legitimately address this complex scientific issue while affording equal protections to the U.S. economy - ***these are not mutually exclusive principles***.

Furthermore, it is difficult for the American manufacturer to understand how adding new regulatory burdens with undefined indirect costs <u>and</u> increasing direct costs of everything from fuel to electricity will not harm domestic industry. You already know the studies published by organizations such as The Beacon Hill Institute, Heritage Foundation and the National

[2] http://jlarc.virginia.gov/reports/Rpt342.pdf

Association of Manufacturers. The Beacon Hill Institute report estimated that Waxman-Markey will cost Virginians in excess of $25 billion by 2050. The Heritage Foundation estimates that Virginians will pay $500 more per household for electricity, and gasoline prices will increase 64 cents per gallon. Finally, the National Association of Manufacturers projects that Virginians may pay as much as $159 per metric ton of CO_2 emitted annually, 64.3% more for natural gas and Virginia should brace for a loss of 56,400 jobs by 2030 (see Appendix C).

Contrast these costs with the fact that Virginia manufacturers have lost over 100,000 jobs in less than 20 years and Virginia has lost billions in economic activity during that same period and ask yourself if this protects domestic jobs and the environment?

On June 6, 2008, ten (10) US Senators, including Virginia's Senator Jim Webb co-signed a letter to you, Senator Boxer, and Senator Reid. In that letter, the Senators stated that one of their principles was to "Protect U.S. Manufacturing Jobs and Strengthen International Competitiveness." The Senators went on to state that, "The final bill must include enhanced safeguards to ensure a truly equitable and effective global effort that minimizes harm to the U.S. economy and protects American jobs." We agree[3].

In closing, the Virginia Manufacturers Association wants Congress to develop responsible policies that protect domestic jobs and the environment. We are concerned that these bills will "cap" industrial competitiveness and "trade" domestic manufacturing jobs abroad for an entirely undefined environmental benefit. We can do better and we must do better.

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[3] Virginia Climate Change Council, Statement of Principles, 2008 - http://www.vamanufacturers.com/publications/climatechangestatementofprinciples.pdf.

APPENDIX A

Table 6. Reserves of fossil fuels plus technically recoverable undiscovered oil and natural gas

	Total fossil fuel proved reserves	Estimated undiscovered oil & gas (Billion BOE, USGS[a])	TOTAL FOSSIL FUELS[b] (Billion BOE)
United States	969.7	351.5	1321.3
Russia	954.9	293.7	1248.6
Saudi Arabia	311.6	231.3	543.0
China	465.6	28.4	494.0
Iran	311.6	114.3	425.9
Canada	214.1	7.2	221.3
Kazakhstan	166.7	33.7	200.4
Iraq	134.8	68.4	203.3
Qatar	175.6	12.1	187.7
Venezuela	118.3	38.1	156.4
United Arab Emirates	135.8	16.2	152.0
Nigeria	69.5	63.4	133.0
Brazil	41.4	79.4	120.8
Kuwait	113.9	4.7	118.6
Libya	51.1	10.8	61.9

BOE means Barrels of Oil Equivalent

a. U.S. Geological Survey, World Petroleum Assessment, 2000, http://energy.cr.usgs.gov/WEcont/WEMap.pdf; mean values of estimates are used for foreign countries. U.S. number is taken from values in Table 3.

b. Total Fossil Fuels in this table include the technically recoverable reserves of oil, natural gas, and coal from Table 5, plus estimates of undiscovered oil and natural gas from the USGS World Petroleum Assessment. No global estimates of undiscovered coal exist.

Source: Congressional Research Service, http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=01feb68b-ef57-4748-8f5c-d88c0e7d6bd5

APPENDIX B

RITA RESEARCH AND INNOVATIVE TECHNOLOGY ADMINISTRATION
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Table 4-49: U.S. Carbon Dioxide Emissions from Energy Use by Sector

(Million metric tons of carbon)

Excel | CSV

Sector	(R) 1990	(R) 1991	(R) 1992	(R) 1993	(R) 1994	(R) 1995	(R) 1996	(R) 1997	(R) 1998	(R) 1999	(R) 2000	(R) 2001	(R) 2002	(R) 2003	(R) 2004	(R) 2005	(R) 2006	(P) 2007
Total U.S. CO_2 Emissions from energy use by sector	**1,368.8**	**1,355.6**	**1,382.6**	**1,411.3**	**1,432.8**	**1,447.6**	**1,468.5**	**1,520.9**	**1,531.2**	**1,548.2**	**1,598.9**	**1,580.4**	**1,587.3**	**1,600.2**	**1,627.0**	**1,629.5**	**1,610.8**	**1,633.7**
Transportation	**431.8**	**425.8**	**431.5**	**439.2**	**450.4**	**458.7**	**470.5**	**475.8**	**485.3**	**498.8**	**510.7**	**504.7**	**515.6**	**517.4**	**534.2**	**542.1**	**549.1**	**549.3**
Natural gas	9.9	9.0	8.6	9.3	10.3	10.5	10.7	11.4	9.5	9.6	9.7	9.5	10.3	9.2	8.7	9.1	9.1	9.7
Electricity	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.2	1.3	1.3	1.3	1.4
Petroleum	420.8	415.9	421.8	429.0	439.3	447.3	458.8	463.3	474.7	487.9	499.9	494.3	504.4	507.0	524.2	531.7	538.7	538.3
Motor gasoline	252.3	260.5	264.4	272.6	275.9	280.5	285.6	288.2	296.6	304.1	306.0	307.4	315.2	316.2	322.1	322.7	323.4	321.9
Liquid petroleum gas	0.4	0.3	0.3	0.3	0.5	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.5	0.5	0.5
Jet fuel	60.7	58.7	56.2	58.7	61.0	62.6	63.3	63.9	64.9	66.9	69.2	66.2	64.6	63.1	65.4	67.2	65.3	64.9
Distillate fuel	73.0	71.8	73.5	75.7	80.4	83.7	89.2	93.2	96.0	99.8	103.9	105.6	107.6	113.0	118.3	121.2	127.9	128.5
Residual fuel	21.8	22.0	23.0	19.4	19.0	18.6	18.3	15.3	14.5	14.3	19.1	12.6	14.5	12.3	15.9	18.0	19.5	20.0
Lubricants	1.8	1.6	1.6	1.7	1.7	1.7	1.6	1.7	1.8	1.8	1.8	1.7	1.5	1.5	1.5	1.5	1.5	1.5
Aviation gas	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.7	0.6	0.6
Industrial	**460.0**	**448.3**	**468.8**	**466.2**	**474.4**	**474.1**	**488.7**	**496.4**	**489.5**	**483.0**	**487.2**	**467.9**	**467.8**	**468.6**	**475.7**	**456.0**	**450.6**	**447.1**
Residential	**262.3**	**266.8**	**266.9**	**283.4**	**281.6**	**283.4**	**299.8**	**297.2**	**299.1**	**305.6**	**322.3**	**318.8**	**320.2**	**334.0**	**332.9**	**342.2**	**326.7**	**340.7**
Commercial	**214.8**	**215.0**	**215.5**	**222.5**	**226.4**	**231.4**	**239.7**	**251.7**	**257.3**	**260.6**	**276.6**	**279.2**	**277.8**	**290.1**	**284.2**	**289.1**	**284.4**	**296.5**
Total U.S. CO_2 Emissions (incl. adj. and other sources)[a]	**1,369.3**	**1,356.3**	**1,386.4**	**1,420.1**	**1,443.8**	**1,458.5**	**1,509.2**	**1,530.1**	**1,537.5**	**1,556.6**	**1,606.9**	**1,583.8**	**1,603.6**	**1,619.5**	**1,642.7**	**1,645.0**	**1,621.4**	**1,642.2**

ACCF and NAM applied input assumptions under two scenarios (high cost and low cost) investigating the sensitivity of assumptions that have proven in the past to significantly impact the cost of limiting CO2 emissions from energy. The ACCF-NAM input assumptions embody judgment on the likely cost and availability of new technologies in the early decades of a long-term effort to reduce greenhouse gas emissions as well as energy efficiency and renewable electricity standards. These assumptions include the availability of nuclear power technology for electric generation, the availability of carbon capture and storage for more efficient coal and natural gas-based power generation technologies, the availability of wind and biomass technologies. The ACCF-NAM input assumptions also included assumptions regarding the likely availability of domestic and international offsets - - key factors influencing analysis of the cost of limiting greenhouse gas emissions (see Appendix a for assumptions).

Results of the ACCF-NAM Analysis of the Waxman-Markey Bill (H.R. 2454)

The NEMS/ACCF-NAM 2 model study's findings indicate substantial and growing impacts to consumers and the economy of meeting the increasingly stringent emission targets through 2030 established by H.R.2454. Among the NEMS/ACCF-NAM 2 study's general findings are:

• U.S. economic growth slows:
U.S. economic growth slows under the Waxman Markey bill (H.R. 2454), especially in the post 2020 period as the free emission allowances are phased out for both energy producers and energy consumers. In 2030, the inflation adjusted, annual GDP level is reduced by 1.8% (or $419 billion) under the low cost scenario and by 2.4% (or $571 billion) under the high cost scenario, compared to the baseline forecast (See Table 1 for results and baseline forecasts). To put these GDP losses in perspective, in 2008 the Federal government spent $612 billion on social security payments to retirees. Looked at another way, if GDP levels are reduced by $571 billion in 2030, Federal and State tax receipts will be approximately $170 billion lower that year since Federal and State governments take approximately 30 cents out of every dollar of GDP. Thus, government budgets will be harder to meet.

Over the entire 18 year period (2012-2030) covered by ACCF/NAM analysis, cumulative GDP losses are substantial, ranging from $2.2 trillion dollars under the low cost case to $3.1 trillion under the high cost case. Again, the hit to Federal and State budgets is large, cumulative tax receipts will be reduced by between $670 billion and $930 billion compared to the baseline forecast. Given the size of projected Federal deficits and State budget receipt shortfalls, policymakers may want to think carefully before imposing the Waxman Markey bill on the already struggling U.S. economy.

• Industrial production begins to decline:
Industrial production (manufacturing, mining and electric utilities) begins to decline immediately in 2012, relative to the baseline forecast, under the Waxman Markey bill. In 2030, U.S. industrial output levels are reduced by between 5.3 % and 6.5 % under the low and high cost scenarios. A hallmark of economic downturns and recessions is a slowdown in the growth rate or an absolute decline in the level of industrial output. Clearly, the negative impact on industrial output of the Waxman Markey bill would make it harder to keep the U.S. economy out of recession or sluggish growth insufficient to restore job growth.

• Employment is negatively impacted:
Employment is negatively impacted by Waxman Markey, even when additional "green" jobs are factored in. Over the 2012-2030 period, total U.S. employment averages between 420,000 and 610,000 fewer jobs each year under the low and high cost scenarios than under the baseline forecast. By 2030, there are between 1,790,000 and 2,440,000 fewer jobs in the overall economy. Manufacturing employment is hard hit: in 2030 there are between 580,000 and 740,000 fewer jobs, or between a 6 and 7 percent reduction in total manufacturing employment in the U.S compared to the baseline forecast. On average, over the 2012-2030 period, the manufacturing sector absorbs 59 to 66 percent of the overall job losses caused by the Waxman Markey bill.

APPENDIX C

Analysis of the Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using the National Energy Modeling System (NEMS/ACCF-NAM 2)

EXECUTIVE SUMMARY

Introduction:

The American Council for Capital Formation (ACCF)[1] and the National Association of Manufacturers (NAM)[2] contracted with Science Applications International Corporation (SAIC)[3] to analyze the Waxman-Markey bill, the American Clean Energy and Security Act of 2009 (H.R. 2454) to substantially reduce U.S. greenhouse gas (GHG) emissions over the 2012-2050 period. This study uses the NEMS/ACCF-NAM 2[4], the version used in this project of the National Energy Modeling System (NEMS) model, the model used by the U.S. Energy Information Administration (EIA) for its energy forecasting and policy analysis when asked by Congress and other federal agencies to analyze new energy and environmental policy initiatives. NEMS provides a common analytical tool for gaining valuable insights into the likely implications of alternative GHG reduction policy options. Using the model relied on by Congress also ensures that the discussion will focus on the merits of assumptions and policy choices rather than methodology. In the end, the use of the ACCF-NAM version of NEMS in this study supports and supplements congressional consideration of alternatives and enhances opportunities to identify commonalities, strengthen the legislation, and find solution paths. This study was performed by SAIC, independent of EIA.[5]

The ACCF and NAM believe it important to fully and realistically examine the potential costs that enactment of Waxman-Markey bill)[6] would impose on the U.S. economy. The Waxman-Markey bill requires an 83 percent reduction in CO2e compared to 2005 levels by the year 2050. It is well recognized that the cost to U.S. consumers and employers of implementing greenhouse gas (GHG) emission reductions is highly dependent on the market penetration achieved by key technologies and the availability of carbon offsets by 2030. Understanding the potential economic impacts at the national, state and individual household levels can help guide choices on climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies need to include consideration of impacts on energy security, economic growth, and U.S. competitiveness. This project is designed to assist in this effort.

The ACCF-NAM analysis of the Waxman-Markey bill uses the most recent version of the EIA Annual Energy Outlook, the April AEO2009. This is the third version of the AEO released by EIA for 2009. The April AEO2009 includes the Stimulus Law enacted in February 2009, the American Recovery and Reinvestment Act of 2009 (ARRA), as well as the original Stimulus Law enacted in October 2008, the Energy Improvement and Extension Act of 2008. It also includes a new macroeconomic outlook that took into account the impact of the significant worsening of the ongoing recession that was not included in the earlier versions of the AEO2009.

In the near term, ARRA is projected to decrease the magnitude and duration of the current recession. Further out in the projection period, however, ARRA adversely affects macroeconomic performance as the larger budget deficits that result from the additional spending embedded in the stimulus package cause interest rates to be higher and GDP growth to be lower. NEMS model changes reflect the following programs of ARRA 2009: weatherization, assisted housing, energy efficiency, and conservation block grants; State energy programs; Plug in hybrid and electric vehicle tax credits; tax credits for renewables; Loan guarantees for renewables, biofuels and transmission projects; support for CCS; and, smart grid expenditures.[7]

• Energy prices rise:
Energy prices rise over the 2012-2030 period, due to the various features of the Waxman Markey bill including prices for carbon permits which gradually rise to between \$123 and \$159 dollars per ton of CO_2 by 2030 as well as the renewable portfolio standards, low carbon fuel standards, and energy efficiency standards. Over the past decade, each 1 percent increase in GDP in the U.S. has been accompanied by a 0.3 percent increase in energy use, thus higher energy prices will make it harder to recover from the current recession and to reduce the current high rate of unemployment. The ACCF/NAM study shows that residential electricity prices are 5 to 8 percent higher by 2020, by 2030 electricity prices are between 31 to 50 percent higher. Gasoline prices are also higher. By 2030 prices are up to 20 to 26 % higher than under the baseline forecast.

• Household income drops:
Household income drops under the Waxman Markey bill, even after accounting for rebates to consumers mandated in the bill. In 2030, the decline in annual household income ranges from \$730 in the low cost case to about \$1248 in the high cost case. However the impacts on household income in individual states, especially in the Midwest are more than 40 percent higher than the national average. For example, household income in Illinois is \$1,096 lower in 2030 under the low cost case and \$1,782 lower under the high cost case. Other Midwestern states, like Michigan, Indiana and Kansas show a similar pattern, income losses are much higher than the national average.

CONCLUSIONS

The ACCF/NAM analysis of the Waxman Markey bill shows that there are significant economic costs in terms of slower growth in jobs, household income and GDP from meeting the bill's GHG reduction targets. Given the wide recognition that without strong emission cuts in developing countries like China and India, U.S. emission reductions would have only negligible environmental benefits, policymakers should proceed cautiously as they develop climate change policies.

1. The American Council for Capital Formation (ACCF) (www.accf.org) is a nonprofit, nonpartisan organization dedicated to the advocacy of tax and environmental policies that encourage saving and investment. The ACCF was founded in 1973 and is supported by the voluntary contributions of corporations, associations, foundations, and individuals. The mission of the ACCF is to promote economic growth through sound tax, environmental, and trade policies.

2. The National Association of Manufacturers (NAM) is the nation's largest industrial trade association, representing small and large manufacturers in every industrial sector and in all 50 states. Headquartered in Washington, D.C., the NAM has 11 additional offices across the country. Visit the NAM's award-winning web site at www.nam.org for more information about manufacturing and the economy.

3. SAIC is a FORTUNE 500® scientific, engineering and technology applications company that uses its deep domain knowledge to solve problems of vital importance to the nation and the world, in national security, energy and the environment, critical infrastructure, and health.

4. As noted, the term "NEMS/ACCF-NAM 2" is used in this report to distinguish NEMS runs conducted in this project from NEMS runs conducted by EIA, and from those conducted for ACCF and NAM last year in analyzing the Lieberman-Warner bill (S. 2191).

5. SAIC is a policy-neutral organization. SAIC executed the NEMS/ACCF-NAM 2 model in this project using SAIC's and ACCF/NAM's interpretation of the bill, and input assumptions provided by ACCF/NAM. The modeling was performed independent of EIA. Analysis provided in this report is based on the output from the NEMS/ACCF-NAM 2 model as a result of the ACCF/NAM input assumptions. The input assumptions, opinions and recommendations in this report are those of ACCF and NAM, and do not necessarily represent the views of SAIC.

6. The House of Representatives passed the H.R. 2454 on June 26, 2009 by a vote of 219-212.

7. The details of the implementation are described in, "An Updated Annual Energy Outlook 2009 Reference Case Revisions Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in Economic Outlook," April 2009, Energy Information administration.

Table 1: Economic Impact of the Waxman-Markey Bill (H.R.2454) on the U.S. Economy

	Baseline (ACCF-Ref)			Low Cost Case (W/M)			High Cost Case (W/M)		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
GDP (Billion 2007$)	$ 18,443	$ 21,016	$ 23,802	$ 18,403	$ 20,905	$ 23,384	$ 18,374	$ 20,853	$ 23,231
Loss in GDP (Billion 2007$)				$ 40	$ 112	$ 419	$ 68	$ 164	$ 571
% Loss				0.2%	0.5%	1.8%	0.4%	0.8%	2.4%
Employment (Millions)	157.2	160.7	165.8	157.2	160.4	164.0	157.1	160.2	163.4
Job Loss (Millions)				-0.01	0.33	1.79	0.08	0.52	2.44
% Loss				0.0%	0.2%	1.1%	0.0%	0.3%	1.5%
Industrial Output (Billion 2007$)	$ 7,962	$ 8,570	$ 8,839	$ 7,817	$ 8,305	$ 8,368	$ 7,790	$ 8,254	$ 8,263
Loss in Industrial Output (Billion 2007$)				$ 144	$ 265	$ 471	$ 172	$ 316	$ 575
% Loss				1.8%	3.1%	5.3%	2.2%	3.7%	6.5%
Coal Mining Output (Billion 2007$)	$ 27.4	$ 28.6	$ 29.2	$ 17.6	$ 12.9	$ 7.5	$ 17.0	$ 12.8	$ 7.0
Loss in Coal Mining Output (Billion 2007$)				$ 9.8	$ 15.7	$ 21.7	$ 10.4	$ 15.8	$ 22.2
% Loss				36%	55%	74%	38%	55%	76%
Primary Metals (Billion 2007$)	$ 188	$ 187	$ 164	$ 176	$ 166	$ 127	$ 171	$ 158	$ 116
Loss in Primary Metals Output (Billion 2007$)				$ 12	$ 21	$ 37	$ 17	$ 29	$ 48
% Loss				6%	11%	23%	9%	15%	29%
Carbon Allowance Price (2007$/ Ton CO2)				$ 47.50	$ 76.50	$ 123.21	$ 61.24	$ 98.63	$ 158.85
Average Household income (2007$)	$ 98,929	$ 110,009	$ 121,731	$ 98,811	$ 109,670	$ 121,001	$ 98,679	$ 109,445	$ 120,483
Loss (2007$)				(118)	(339)	(730)	(250)	(564)	(1,248)
% Change				-0.1%	-0.3%	-0.6%	-0.3%	-0.5%	-1.0%
Energy Expenditures (Billion 2007$)	$ 1,480	$ 1,549	$ 1,682	$ 1,538	$ 1,652	$ 1,996	$ 1,584	$ 1,728	$ 2,136
Increase(2007$)				$ 57	$ 103	$ 313	$ 104	$ 179	$ 454
% change				3.9%	6.7%	18.6%	7.0%	11.6%	27.0%
Retail gasoline prices (2007 $/gallon)	$ 3.61	$ 3.69	$ 3.85	$ 3.92	$ 4.13	$ 4.62	$ 4.01	$ 4.28	$ 4.86
% Change				8.4%	12.1%	20.0%	11.1%	16.1%	26.1%
Residential Electricity Price (2007$ Cents/Kwh)	$ 11.10	$ 11.22	$ 11.69	$ 11.66	$ 11.77	$ 15.36	$ 11.98	$ 12.51	$ 17.54
% change				5.0%	4.9%	31.4%	7.9%	11.5%	50.0%
Industrial Electricity Prices (2007 Cents/Kwh	$ 6.45	$ 6.57	$ 6.91	$ 7.26	$ 7.78	$ 10.30	$ 7.84	$ 8.68	$ 12.17
% change				12.5%	18.4%	48.9%	21.5%	32.0%	76.0%
Residential Natural Gas Prices (2007$/Mcf)	$ 12.88	$ 12.93	$ 14.27	$ 12.46	$ 13.55	$ 22.31	$ 12.90	$ 14.24	$ 24.75
% change				-3.3%	4.8%	56.3%	0.1%	10.1%	73.5%
Industrial Natural Gas Prices (2007 $/Mcf)	$ 7.65	$ 7.62	$ 8.85	$ 10.19	$ 12.28	$ 16.55	$ 11.56	$ 14.19	$ 18.89
% change				33.3%	61.0%	87.1%	51.1%	86.3%	113.5%
Electric Utility Coal Prices (2007 $/Ton)	$ 38	$ 39	$ 40	$ 124	$ 180	$ 269	$ 151	$ 224	$ 345
% change				224%	359%	565%	295%	472%	755%
Manufacturing Employment (Millions)	12.0	11.6	10.1	11.8	11.2	9.5	11.7	11.1	9.4
Job Loss (Millions)				0.21	0.38	0.58	0.28	0.49	0.74
% Loss				1.8%	3.3%	5.8%	2.3%	4.2%	7.3%

United States Senate
WASHINGTON, DC 20510

June 6, 2008

The Honorable Harry Reid
Majority Leader
United States Senate
S-221, the Capitol
Washington, D.C. 20510

The Honorable Barbara Boxer
Chairman, Committee on Environment and Public Works
456 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Mr. Leader and Chairman Boxer:

As Democrats from regions of the country that will be most immediately affected by climate legislation, we want to share our concerns with the bill that is currently before the Senate. We commend your leadership in attempting to address one of the most significant threats to this and future generations; however, we cannot support final passage of the Boxer Substitute in its current form.

We believe a federal cap and trade program must not only significantly reduce greenhouse gas emissions but also ensure that consumers and workers in all regions of the U.S. are protected from undue hardship. A federal cap and trade program is perhaps the most significant endeavor undertaken by Congress in over 70 years and must be done with great care. To that point we have laid out the following principles and concerns that must be considered and fully addressed in any final legislation.

- **Contain Costs and Prevent Harm to the U.S. Economy:** We hope that you recognize, as we do, the inherent uncertainty in predicting the costs of achieving the emission caps set forth in this or any climate legislation. While placing a cost on carbon is important, we believe that there must be a balance and a short-term cushion when new technologies may not be available as hoped for or are more expensive than assumed. There are many options to deal with the issue and all should be up for discussion in order to meet our environmental and economic goals. Ultimately, we must strive to form a partnership with regulated industries to help them reduce emissions as they transition from an old energy economy to a new energy economy which will protect both our environment and our economy.

- **Invest Aggressively in New Technologies and Deployment of Existing Technologies:** There is no doubt that we need a technological revolution to enter into a low carbon economy. It is critical that we design effective mechanisms to augment and accelerate government-sponsored technology R&D programs and incentives that will motivate rapid deployment of those technologies without picking winners and losers. We also want to include proposals to provide funding for carbon capture and storage and other critical low carbon technologies in advance of resources being available through the auction of emission allowances. We also need to aggressively deploy existing energy efficiency technologies now to retrofit millions of homes, buildings and manufacturing facilities to reduce electricity costs for everyone.

- **Treat States Equitably:** Just as some groups of consumers will be more severely affected by the cost of compliance, so too will our states. The allocation structure of a cap-and-trade bill must be designed to balance these burdens across states and regions and be sufficiently transparent to be understood.

- **Protect America's Working Families:** Any legislation must recognize that working families are going to be significantly affected by any cap and trade legislation. Price relief for these families must be included in any federal cap and trade program. For instance, one way to provide some relief would be to provide additional allowances to utilities whose electricity prices are regulated, which would help to keep electricity prices low.

- **Protect U.S. Manufacturing Jobs and Strengthen International Competitiveness:** The Lieberman-Warner bill contains a mechanism to protect U.S. manufacturers from international competitors that do not face the same carbon constraints. If this mechanism does not work, or is found to be noncompliant with the World Trade Organization, then the program needs to be modified or suspended. The final bill must include enhanced safeguards to ensure a truly equitable and effective global effort that minimizes harm to the U.S. economy and protects American jobs. Furthermore, we must adequately help manufacturers transition to a low carbon economy to maintain domestic jobs and production.

- **Fully Recognize Agriculture and Forestry's Role:** Agriculture and forestry are not regulated under the bill but they can contribute to reducing emissions by over 20% domestically. Furthermore, international deforestation contributes to 20% of global greenhouse gas emissions. Strong, aggressive and verifiable offset policies can fully utilize the capabilities of our farmers and forests. A strong offset policy can also reduce the costs of a cap and trade program while maintaining our strong environmental goals.

- **Clarify Federal/State Authority:** Congress should adopt a mandatory federal cap-and-trade program that will be the single regulatory regime for controlling greenhouse gas emissions. Existing state laws and initiatives should be integrated into the federal cap-and-trade program where the policies do not conflict. Federal uniformity in this area should be made clear in the statutory language to prevent conflict in regulation, preserve overall efficiency, and ensure harmonization of regulations. Where a conflict exists, federal law needs to clearly prevail.

- **Provide Accountability for Consumer Dollars:** The cap and trade program developed in the Lieberman-Warner bill has the potential to raise over $7 trillion. Much of these funds will be indirectly paid for by consumers through increased energy prices. The federal government has a fundamental obligation to ensure these funds are being spent in a responsible and wise manner. The development of any cap and trade program must recognize the sensitivity of this obligation and eliminate all possibility of waste, fraud or abuse.

We look forward to working with you to ensure that any final bill will address the problems of climate change without imposing undue hardship on our states, key industrial sectors and consumers.

Sincerely,

Debbie Stabenow

John D. Rockefeller IV

Carl Levin

Blanche Lincoln

Mark Pryor

Jim Webb

Evan Bayh

Claire McCaskill

Sherrod Brown

Ben Nelson

Environment and Public Works Committee Hearing
October 28, 2009
Follow-Up Questions for Written Submission
Questions for Vassey

Question from Senator Amy Klobuchar

1. In Minnesota, we have strong, consistent policies in place that have promoted the development of homegrown energy - from biofuels, to biomass, to wind, solar, geothermal and hydro power. The reason we've had this success is that businesses know there will be demand for their products in the future and can plan to develop new products. On a federal level, this consistency has been lacking. As Secretary Chu said in his testimony yesterday, "On-again, off-again incentives will not drive the level of clean energy investment we need." Can you comment on this bill's ability to provide the private sector market certainty for homegrown energy projects and technologies?

Answer from Brett A. Vassey, Virginia Manufacturers Association

Dear Senator Klobuchar:

Virginia may have been one of the first states to develop a comprehensive Energy Plan - http://www.governor.virginia.gov/TempContent/2007_VA_Energy_Plan-Full_Document.pdf. Fortunately, we have taken an incentive approach to our growth, not necessarily a "command and control" regulatory approach. It can work.

Unfortunately, this bill may create as much instability in existing markets as it creates stability in emerging markets. This bill seems to be exclusively focused on providing substantial subsidies to a very small sector of the economy. It also completely ignores the reality of the consumer or the demand aspects of this equation. Consumers want inexpensive, reliable energy and it is essential to the economic competitiveness of this country. Just because you create more government subsidized technologies does not mean that they are sustainable in the private sector.

Most states have regulated utilities and/or municipal and/or cooperatives providing them with retail electricity. Due to the relationships between utilities and state regulatory bodies, like the Virginia State Corporation Commission, there is some level of predictability in the state code about how utilities operate and, in Virginia, how they are incentivized to produce certain outcomes. For example, Virginia allows investor owned utilities to receive certain enhancements to their returns on equity for selling retail electricity that is produced from renewable resources. This government incentive may have allowed for certain renewable projects to go forward due to the knowledge that there would be a government guaranteed return for those companies. The other side of this story is that the power is expensive and the projects have not produced all the jobs in Virginia. So, Virginia consumers may pay for jobs created in other states. This is analogous to the "leakage" issue that I mentioned in my testimony. This bill may give certain preferential treatment to certain technologies for energy production or conservation, but there is no guarantee that jobs to produce those products will be in the United States. Further, there is ample evidence in the scientific and economic community that this bill will be unaffordable for most consumers.

All energy products/technologies, whether solar panels or wind turbines, will have to compete in a global market. US manufacturers already operate at a substantial cost disadvantage due to the mountain of regulatory costs, litigation costs, liability costs, energy costs, labor legacy costs, etc., we have compared to our top 10 trading partners. So, how is it that these products will be all made in the US? It defies 20 years of evidence to the contrary.

If you want to help provide predictability in the private market, create a world-class system of incentives (financial and operational) and work to flatten all costs of all companies against every major international trading partner. If US manufacturers can make products that consumers can afford, they will be made in the US.

For example, shouldn't the bill address fast-track permitting or expanded loan guarantees for nuclear facilities? How about changing the Clean Air Act to allow industrial businesses to switch fuels regularly in response to markets and local biofuel producers? There are thousands of these types of recommendations that would expand the sustainable development of "homegrown" projects and technologies that would not require this concentration of Federal power and taxation.

Thank you for the opportunity to share my thoughts.

Sincerely,

Brett A. Vassey
President & CEO
Virginia Manufacturers Association

Question from Senator George V. Voinovich

1. Mr. Brett Vassey - CEO, Virginia Manufacturing Association - As I am sure you are aware, my state of Ohio has for years been a leader in manufacturing, particularly with smaller mom and pop manufacturers. These manufacturing and design jobs represent thousands of well paying jobs that our economy depends upon. Could you discuss more in detail your concerns that provisions in this climate bill are not sufficient to prevent compliance costs from driving US manufacturing plants, like the ones in Ohio and Virginia overseas? Is it even possible to protect U.S. manufacturers under a cap and trade system?

Answer from Brett A. Vassey, Virginia Manufacturers Association

Dear Senator Voinovich:

It is my opinion that a "cap and trade" system of regulation will only harm domestic manufacturers, particularly those with facilities that cannot be relocated to other countries. It will add direct production costs and undefined indirect costs for operations. Virginia's struggling manufacturing base is already at a substantial cost disadvantage to our top 10 trading partners in everything from taxation to tort costs today. This bill only adds new costs to our load.

Speaking to the indirect "compliance costs," they will be substantial and they are not addressed in this bill. These are like unfunded mandates to us. In fact, Virginia's legislature has already documented the costs of our industry's compliance with Federal and State environmental regulations and estimated those costs are between $606 million and $1.72 billion per year (http://jlarc.virginia.gov/reports/Rpt342.pdf, Chapter 3) today. We would suggest that the Virginia legislature's report is a model for the nation. "Cap & Trade" will only increase costs.

In addition, there was an attempt by our Governor to pre-empt the Federal Greenhouse Gas Reporting system currently in draft rule form at the US EPA during the last two legislative sessions. The indirect compliance costs to 580 industrial businesses targeted by the Virginia legislation to comply with a state-based GHG reporting system would have cost between $15.9 and $26.5 million per year. It should also be noted that these indirect compliance costs only represented monitoring and administration - there are still other substantial indirect compliance costs that have not been valued (see attached chart).

The direct costs estimated by Heritage, NAM and Beacon Hill are equally unaffordable. Manufacturers, in particular, are regressively taxed under this system. We will pay for the direct costs of fuel and electricity providers in order to run our plants. Our suppliers will pass along their increased costs to us in the form of more expensive components and/or services. Additionally, this system will tax and confiscate our productive capacity without compensation. This is the "trifecta" of costs.

The challenge for manufacturers, particularly small and medium domestic manufacturers, is that many of their product sales are to large retail operations that have a goal of providing the cheapest price to the consumer. Under "cap and trade," many of our food, paper, chemical, automotive/transportation and metals businesses will simply not be price competitive – this represents over 60,000 jobs or 25% of our entire manufacturing base in the Commonwealth.

Thank you for your leadership on manufacturing issues for our nation.

Sincerely,

Brett A. Vassey
President & CEO
Virginia Manufacturers Association

VIRGINIA GREENHOUSE GAS REPORTING PROPOSAL
ECONOMIC IMPACT ESTIMATE

The chart below details the costs associated with any environmental regulation. This cost chart was developed by the Joint Legislative Audit & Review Commission. It is difficult to estimate the costs of a stand-alone state GHG reporting program for each affected site, but participants in voluntary private sector reporting systems, like the Chicago Climate Exchange, estimate their monitoring and administration costs alone range from $30,000 to $50,000.

These voluntary program costs do not include potential fees, operating costs, capital costs and opportunity costs, therefore, the total cost to each site for complying with the reporting, verification, "rigorous" accounting and records maintenance provisions of this statute could be substantial. At the very least, this regulation will be an additional cost to stationary sources and not all sources have the same internal capacity to readily comply, therefore, costs will vary by site. There is no similar evaluative model for estimating the total costs to DEQ for administering this regulation.

Direct Expenditures				Other Costs	
Staff Time	Fees and Penalties	Operating Costs	Capital Expenditures	Opportunity Costs	Special Costs
• Filling out permit applications • Reporting emissions levels to state or federal agencies • Evaluation of pollution releases according to regulatory mandate • Legal and other paperwork	• Operating permit fees • Fines and penalties for environmental noncompliance	• Maintenance of pollution control equipment • Monitoring and testing of pollution emissions • Costs to administer pollution control programs	• Purchase and installation of pollution control equipment	• Disrupted productivity due to compliance with pollution controls	• Altered decision-making due to regulatory requirements

ESTIMATED STAFF & SPECIAL COSTS ONLY: $15,900,000 - $26,500,000

Senator BOXER. Thank you so much.

So, we are now going to be, each of us, having 5 minutes each to question. And we will go with the early bird rule.

I would like to start off, Mr. Klesse, with you, because you said something very strongly, and I know you feel it, and that is American security is threatened by this legislation, by the Kerry-Boxer legislation. Those are your words.

I would just like to say the opposite is true. And I am going to put into the record, to go along with your statement, the Center for Naval Analysis. They did a paper called National Security and the Threat of Climate Change. And some of the people on there are General Gordon Sullivan, Admiral Frank Bauman, Lieutenant General Lawrence Farrell, and they are from every area of our military, Anthony Zinni. So, I am just going to say I am putting three pages into the record.

One statement here is projected climate change poses a serious threat to America's national security. The other is climate change acts as a threat multiplier for instability in some of the most volatile regions of the world. And another is the U.S. should commit to a stronger national and international role to help stabilize climate change at levels that will avoid significant disruption to global security and stability.

So, I just wanted to put this into the record because one of the reasons that we have so much strong support from these groups of military people, and also we have seen reports from the CIA, and I am going back to Republican Administrations, is because of the threat if we do nothing.

And another point I want to counter, because you are very clear on what you are saying, is that you worry about the jobs in California, and of course, Senator Feinstein and I we are very worried. As we look at the studies of job creation, I think that Ms. Gordon spoke to this, Mr. Foster and Mr. Brehm, the one area of growth that we have seen, even with this horrible recession which, as you know, has put out of work so many people basically starting with the housing sector and the lack of construction, has been clean energy jobs.

And we have seen, you know, 400 new solar businesses spring up. We have seen 125,000 new jobs. We have seen this, the percentages are there already, even without this legislation.

So, I have not yet seen a study that shows that we are not going to be dependent on domestic oil. Our goal is to stop sending $1 billion out of the country for foreign oil, which we get from countries who do not like us, and keep the $1 billion here.

[The referenced paper follows:]

NATIONAL SECURITY AND THE THREAT OF CLIMATE CHANGE

SecurityAndClimate.cna.org

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Research that works, for work that matters

NATIONAL SECURITY AND THE THREAT OF CLIMATE CHANGE

[illegible]

[illegible], USA (Ret.)
[illegible]

[illegible], USN (Ret.)

[illegible], USAF (Ret.)

[illegible], USN (Ret.)

[illegible] (Ret.)

[illegible], USN (Ret.)

[illegible], USN (Ret.)

[illegible], USN (Ret.)

[illegible], USN (Ret.)

[illegible] Wald, USAF (Ret.)

[illegible] Zinni, USMC (Ret.)

To the reader,

During our decades of experience in the U.S. military, we have addressed many national security challenges, from containment and deterrence of the Soviet nuclear threat during the Cold War to terrorism and extremism in recent years.

Global climate change presents a new and very different type of national security challenge.

Over many months and meetings, we met with some of the world's leading climate scientists, business leaders, and others studying climate change. We viewed their work through the lens of our military experience as warfighters, planners, and leaders. Our discussions have been lively, informative, and very sobering.

Carbon dioxide levels in the atmosphere are greater now than at any time in the past 650,000 years, and average global temperature has continued a steady rise. This rise presents the prospect of significant climate change, and while uncertainty exists and debate continues regarding the science and future extent of projected climate changes, the trends are clear.

The nature and pace of climate changes being observed today and the consequences projected by the consensus scientific opinion are grave and pose equally grave implications for our national security. Moving beyond the arguments of cause and effect, it is important that the U.S. military begin planning to address these potentially devastating effects. The consequences of climate change can affect the organization, training, equipping, and planning of the military services. The U.S. military has a clear obligation to determine the potential impacts of climate change on its ability to execute its missions in support of national security objectives.

Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world, and it presents significant national security challenges for the United States. Accordingly, it is appropriate to start now to help mitigate the severity of some of these emergent challenges. The decision to act should be made soon in order to plan prudently for the nation's security. The increasing risks from climate change should be addressed now because they will almost certainly get worse if we delay.

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We are thankful to several people for their support of this effort. Rear Adm. Richard Pittenger, USN (Ret.) of the Woods Hole Oceanographic Institution, and Dr. Fiona Horsfall of the National Oceanic and Atmospheric Administration provided many valuable insights into climate science and reviewed our draft report. Dr. Robert Frosch, former assistant secretary of the Navy for research and development and former NASA administrator, currently at Harvard University, also reviewed our draft report and provided suggestions for improvement regarding the science of climate change. Dr. Kent Butts of the Army War College, Dr. Geoffrey D. Dabelko of the Woodrow Wilson International Center for Scholars, and Franklin D. Kramer, former assistant secretary of defense, reviewed our report and provided valuable comments on sources of conflict and security issues related to climate change.

We thank the following persons for briefing the Military Advisory Board: Dr. James Hansen, lead climate scientist and director, NASA Goddard Institute for Space Studies; Dr. Anthony Janetos of the H. John Heinz III Center for Science, Economics and the Environment; Dr. Richard Moss, senior director, Climate and Energy, United Nations Foundation, formerly director of the U.S. Global Change Research Program Office; Mr. Justin Mundy, senior advisor to the Special Representative on Climate Change, UK Foreign and Commonwealth Office; Maj. Gen. Richard Engel, USAF (Ret.), deputy national intelligence officer for science and technology, National Intelligence Council; Mr. Randy Overbey, former president, Alcoa Primary Metals Development; Mr. Kenneth Colburn, of the Center for Climate Strategies; and Dr. Robert Socolow of Princeton University.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The purpose of this study is to examine the national security consequences of climate change. A dozen of the nation's most respected retired admirals and generals have served as a Military Advisory Board to study how climate change could affect our nation's security over the next 30 to 40 years—the time frame for developing new military capabilities.

The specific questions addressed in this report are:

1. What conditions are climate changes likely to produce around the world that would represent security risks to the United States?
2. What are the ways in which these conditions may affect America's national security interests?
3. What actions should the nation take to address the national security consequences of climate change?

The Military Advisory Board hopes these findings will contribute to the call President Bush made in his 2007 State of the Union address to "...help us to confront the serious challenge of global climate change" by contributing a new voice and perspective to the issue.

FINDINGS

Projected climate change poses a serious threat to America's national security.

The predicted effects of climate change over the coming decades include extreme weather events, drought, flooding, sea level rise, retreating glaciers, habitat shifts, and the increased spread of life-threatening diseases. These conditions have the potential to disrupt our way of life and to force changes in the way we keep ourselves safe and secure.

In the national and international security environment, climate change threatens to add new hostile and stressing factors. On the simplest level, it has the potential to create sustained natural and humanitarian disasters on a scale far beyond those we see today. The consequences will likely foster political instability where societal demands exceed the capacity of governments to cope.

Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world. Projected climate change will seriously exacerbate already marginal living standards in many Asian, African, and Middle Eastern nations, causing widespread political instability and the likelihood of failed states.

Unlike most conventional security threats that involve a single entity acting in specific ways and points in time, climate change has the potential to result in multiple chronic conditions, occurring globally within the same time frame. Economic and environmental conditions in already fragile areas will further erode as food production declines, diseases increase, clean water becomes increasingly scarce, and large populations move in search of resources. Weakened and failing governments, with an already thin margin for survival, foster the conditions for internal conflicts, extremism, and movement toward increased authoritarianism and radical ideologies.

The U.S. may be drawn more frequently into these situations, either alone or with allies, to help provide stability before conditions worsen and are exploited by extremists. The U.S. may also be called upon to undertake stability and reconstruction efforts once a conflict has begun, to avert further disaster and reconstitute a stable environment.

Projected climate change will add to tensions even in stable regions of the world. The U.S. and Europe may experience mounting pressure to accept large numbers of immigrant and refugee populations as drought increases and food production declines in Latin America and Africa. Extreme weather events and natural disasters, as the U.S. experienced with Hurricane Katrina, may lead to increased missions for a number of U.S. agencies, including state and local governments, the Department of Homeland Security, and our already stretched military, including our Guard and Reserve forces.

Climate change, national security, and energy dependence are a related set of global challenges. As President Bush noted in his 2007 State of the Union speech, dependence on foreign oil leaves us more vulnerable to hostile regimes and terrorists, and clean domestic energy alternatives help us confront the serious challenge of global climate change. Because the issues are linked, solutions to one affect the other. Technologies that improve energy efficiency also reduce carbon intensity and carbon emissions.

RECOMMENDATIONS OF THE MILITARY ADVISORY BOARD:

1. The national security consequences of climate change should be fully integrated into national security and national defense strategies.

As military leaders, we know we cannot wait for certainty. Failing to act because a warning isn't precise enough is unacceptable. The intelligence community should incorporate climate consequences into its National Intelligence Estimate. The National Security Strategy should directly address the threat of climate change to our national security interests. The National Security Strategy and National Defense Strategy should include appropriate guidance to military planners to assess risks to current and future missions caused by projected climate change. The next Quadrennial Defense Review should examine the capabilities of the U.S. military to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events, pandemic disease events, and other related missions.

2. The U.S. should commit to a stronger national and international role to help stabilize climate change at levels that will avoid significant disruption to global security and stability.

Managing the security impacts of climate change requires two approaches: mitigating the effects we can control and adapting to those we cannot. The U.S. should become a more constructive partner with the international community to help build and execute a plan to prevent destabilizing effects from climate change, including setting targets for long term reductions in greenhouse gas emissions.

3. The U.S. should commit to global partnerships that help less developed nations build the capacity and resiliency to better manage climate impacts.

As President Bush noted in his State of the Union speech, "Our work in the world is also based on a timeless truth: To whom much is given, much is required." Climate forecasts indicate countries least able to adapt to the consequences of climate change are those that will be the most affected. The U.S. government should use its many instruments of national influence, including its regional commanders, to assist nations at risk build the capacity and resiliency to better cope with the effects of climate change. Doing so now can help avert humanitarian disasters later.

4. The Department of Defense should enhance its operational capability by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power through energy efficiency.

Numerous Department of Defense studies have found that combat forces would be more capable and less vulnerable by significantly reducing their fuel demand. Unfortunately, many of their recommendations have yet to be implemented. Doing so would have the added benefit of reducing greenhouse gas emissions.

5. The Department of Defense should conduct an assessment of the impact on U.S. military installations worldwide of rising sea levels, extreme weather events, and other projected climate change impacts over the next 30 to 40 years.

Many critical defense installations are located on the coast, and several strategically important ones are on low-lying Pacific islands. Sea level rise and storm surges will threaten these facilities. Planning and action can make these installations more resilient. Lack of planning can compromise them or cause them to be inundated, compromising military readiness and capability.

ABOUT THE REPORT

To better inform U.S. policymakers and the public about the threats to national security from global climate change, the CNA Corporation, a nonprofit national security analysis organization, convened a panel of retired senior military officers and national security experts and conducted an assessment of the national security implications of global climate change. In this context, we define national security to refer to the influence of climate change on geo-strategic balances and world events that could likely involve U.S. military forces or otherwise affect U.S. strategic interests anywhere in the world.

The Military Advisory Board consisted of retired flag and general officers from all four services, including service chiefs and some who served as regional combatant commanders (a regional combatant commander is a four-star officer who commands all U.S. forces in a given region of the world). The Military Advisory Board and the study team received briefings from the U.S. intelligence community, climate scientists, and business and state leaders. They also traveled to the United Kingdom to meet with high-level government and business leaders to learn what actions the United Kingdom is taking to address the threat of climate change. Members of the Military Advisory Board also presented their own views, based on experience, of the security effects of climate change on various regions of the world.

This report documents the results of that effort. We start with a discussion of the geo-strategic implications of climate change in the general sense—that is, how climate change can foster instability and affect international security. We then apply this background to address specific regional security challenges in Africa, Asia, the Middle East, Europe, and the Americas. That is followed by a discussion of the challenges from climate change that can have a direct impact on military systems and operations. We conclude with a set of findings and recommendations related to mitigation, adaptation, and preparation—specific actions the U.S. government should take in response to the challenges presented by climate change. Appendices provide background on members of the Military Advisory Board, and very briefly summarize the science of climate change and ways in which the earth's environment may potentially change.

CLIMATE CHANGE AND THE SCOPE OF THIS STUDY

Although there is a great deal of agreement among the world's climate scientists regarding the overall picture of a changing climate, there is also some disagreement about the extent of future changes.

Regardless of this continuing discussion, the board's view is quite clear: The potential consequences of climate change are so significant that the prudent course of action is to begin now to assess how these changes may potentially affect our national security, and what courses of action, if any, our nation should take.

This approach shows how a military leader's perspective often differs from the perspectives of scientists, policymakers, or the media. Military leaders see a range of estimates and tend not to see it as a stark disagreement, but as evidence of varying degrees of risk. They don't see the range of possibilities as justification for inaction. Risk is at the heart of their job: They

VOICES OF EXPERIENCE

GENERAL GORDON R. SULLIVAN, USA (Ret.)

Chairman, Military Advisory Board | Former Chief of Staff, U.S. Army

ON RISK

Former U.S. Army Chief of Staff Gordon Sullivan enjoys a good debate. But he also knows there are times when debate must stop and action must begin. With respect to climate change, he says that time has arrived.

"We seem to be standing by and, frankly, asking for perfectness in science," Gen. Sullivan said. "People are saying they want to be convinced, perfectly. They want to know the climate science projections with 100 percent certainty. Well, we know a great deal, and even with that, there is still uncertainty. But the trend line is very clear."

"We never have 100 percent certainty," he said. "We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield. That's something we know. You have to act with incomplete information. You have to act based on the trend line. You have to act on your intuition sometimes."

"We never have 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield."

In discussing how military leaders manage risk, Gen. Sullivan noted that significant attention is often given to the low probability/high consequence events. These events rarely occur but can have devastating consequences if they do. American families are familiar with these calculations. Serious injury in an auto accident is, for most families, a low probability/high consequence event. It may be unlikely, but we do all we can to avoid it.

During the Cold War, much of America's defense efforts focused on preventing a Soviet missile attack—the very definition of a low probability/high consequence event. Our effort to avoid such an unlikely event was a central organizing principle for our diplomatic and military strategies.

When asked to compare the risks of climate change with those of the Cold War, Gen. Sullivan said, "The Cold War was a specter, but climate change is inevitable. If we keep on with business as usual, we will reach a point where some of the worst effects are inevitable."

"If we don't act, this looks more like a high probability/high consequence scenario," he added.

Gen. Sullivan shifted from risk assessment to risk management.

"In the Cold War, there was a concerted effort by all leadership—political and military, national and international—to avoid a potential conflict," he said. "I think it was well known in military circles that we had to do everything in our power to create an environment where the national command authority—the president and his senior advisers—were not forced to make choices regarding the use of nuclear weapons.

"The situation, for much of the Cold War, was stable," Gen. Sullivan continued. "And the challenge was to keep it stable, to stop the catastrophic event from happening. We spent billions on that strategy.

"Climate change is exactly the opposite. We have a catastrophic event that appears to be inevitable. And the challenge is to stabilize things—to stabilize carbon in the atmosphere. Back then, the challenge was to stop a particular action. Now, the challenge is to inspire a particular action. We have to act if we're to avoid the worst effects."

assess and manage the many risks to America's security. Climate change, from the Military Advisory Board's perspective, presents significant risks to America's national security. Before explaining some of those risks, we touch on an important scientific point.

A global average temperature increase of 1.3°F (plus or minus 0.3°F) occurred over the twentieth century. But the temperature change on its own is not what shapes this security assessment. Rather, it is the impact that temperature increases can have on natural systems, including:

- Habitats
- Precipitation patterns
- Extreme weather events
- Ice cover
- Sea level

Throughout this report, we do not attempt to tie our findings regarding security implications to any one particular projection of future temperature changes, precipitation changes, or sea level rise whether due to ocean expansion or ice sheet breakup. Rather, our goal is to articulate the possible security implications of climate change and to consider mitigating steps the nation could take as part of an overall national security plan.

GEO-STRATEGIC IMPLICATIONS
OF CLIMATE CHANGE

GEO-STRATEGIC IMPLICATIONS OF CLIMATE CHANGE

One reason human civilizations have grown and flourished over the last five millennia is that the world's climate has been relatively stable. However, when climates change significantly or environmental conditions deteriorate to the point that necessary resources are not available, societies can become stressed, sometimes to the point of collapse [1].

For those concerned about national security, stability is a primary goal. Maintaining stability within and among nations is often a means of avoiding full-scale military conflicts. Conversely, instability in key areas can threaten our security. For these reasons, a great deal of our national security efforts in the post-World War II era have been focused on protecting stability where it exists and trying to instill it where it does not.

This brings us to the connection between climate change and national security.

As noted, climate change involves much more than temperature increases. It can bring with it many of the kinds of changes in natural systems that have introduced instability among nations throughout the centuries.

In this chapter, we consider some of the ways climate change can be expected to introduce the conditions for social destabilization. The sources of tension and conflict we discuss here are certainly not solely due to climate change; they have been discussed by the national security community for many years. However, climate change can exacerbate many of them [2].

For example:

- Some nations may have impaired access to food and water.
- Violent weather, and perhaps land loss due to rising sea levels and increased storm surges, can damage infrastructure and uproot large numbers of people.
- These changes, and others, may create large number of migrants. When people cross borders in search of resources, tensions can arise.

When climates change significantly or environmental conditions deteriorate to the point that necessary resources are not available, societies can become stressed, sometimes to the point of collapse.

- Many governments, even some that look stable today, may be unable to deal with these new stresses. When governments are ineffective, extremism can gain a foothold.
- While the developed world will be far better equipped to deal with the effects of climate change, some of the poorest regions may be affected most. This gap can potentially provide an avenue for extremist ideologies and create the conditions for terrorism.

THE DESTABILIZING IMPACTS OF CLIMATE CHANGE

REDUCED ACCESS TO FRESH WATER

Adequate supplies of fresh water for drinking, irrigation, and sanitation are the most basic prerequisite for human habitation. Changes in rainfall, snowfall, snowmelt, and glacial melt have significant effects on fresh water supplies, and climate change is likely to affect all of those things. In some areas of the Middle East, tensions over water already exist.

Mountain glaciers are an especially threatened source of fresh water [3]. A modest rise in temperature of about 2° to 4°F in mountainous

VOICES OF EXPERIENCE

VICE ADMIRAL RICHARD H. TRULY, USN (Ret.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

ON DRAWING HIS OWN CONCLUSIONS

Retired Vice Adm. Richard H. Truly was a space shuttle commander and NASA administrator and is a member of the National Academy of Engineering. When he began service as director of the Department of Energy's National Renewable Energy Laboratory in 1997, he reminded his staff that he would be confronted with a new set of issues.

"I told them that I was unencumbered with experience or knowledge of the energy business, and that I would need their help," Adm. Truly said. "I had a pretty steep learning curve."

One of the first issues he was asked to consider was the extent to which fossil fuel emissions were affecting the climate.

"I wasn't convinced by a person or any interest group—it was the data that got me."

"I was a total agnostic," Truly said. "I had spent most of my life in the space and aeronautics world, and hadn't really wrestled with this. I was open-minded."

"Over the course of the next few years, I started really paying attention to the data. When I looked at what energy we had used over the past couple of centuries and what was in the atmosphere today, I knew there had to be a connection. I wasn't convinced by a person or any interest group—it was the data that got me. As I looked at it on my own, I couldn't come to any other conclusion. Once I got past that point, I was utterly convinced of this connection between the burning of fossil fuels and climate change. And I was convinced that if we didn't do something about this, we would be in deep trouble."

Adm. Truly noted an ironic twist about his path to this conclusion. "I was NASA administrator when Jim Hansen was first talking about these issues," he said, referring to NASA's top climate scientist. "But I was focused elsewhere then, and I should have listened more closely. I didn't become a convert until I saw the data on my own."

"The stresses that climate change will put on our national security will be different than any we've dealt with in the past. For one thing, unlike the challenges that we are used to dealing with, these will come upon us extremely slowly, but come they will, and they will be grinding and inexorable. But maybe more challenging is that they will affect every nation, and all simultaneously. This is why we need to study this issue now, so that we'll be prepared and not overwhelmed by the required scope of our response when the time comes."

When asked about his experience twenty-five years ago in space, and how it affects him today, Adm. Truly said, "It does change you, there's no doubt about it. I have images burned in my mind that will never go away—images of the earth and its fragility. I was a test pilot. I was an aviator. I was not an environmentalist. But I do love the natural environment, and seeing the earth from space was the experience that I return to when I think about what we know now about the climate."

"One of the things that struck me on my first day in space is that there is no blue sky. It's something that every human lives with on Earth, but when you're in space, you don't see it. It looks like there's nothing between you and the surface of the earth. And out beyond that, it looks like midnight, with only deep black and stars."

"But when you look at the earth's horizon, you see an incredibly beautiful, but very, very thin line. You can see a tiny rainbow of color. That thin line is our atmosphere. And the real fragility of our atmosphere is that there's so little of it."

regions can dramatically alter the precipitation mix by increasing the share falling as rain while decreasing the share falling as snow. The result is more flooding during the rainy season, a shrinking snow/ice mass, and less snowmelt to feed rivers during the dry season [4]. Forty percent of the world's population derives *at least* half of its drinking water from the summer melt of mountain glaciers, but these glaciers are shrinking and some could disappear within decades. Several of Asia's major rivers—the Indus, Ganges, Mekong, Yangtze, and Yellow—originate in the Himalayas [4]. If the massive snow/ice sheet in the Himalayas—the third-largest ice sheet in the world, after those in Antarctic and Greenland—continues to melt, it will dramatically reduce the water supply of much of Asia.

Most countries in the Middle East and northern Africa are already considered water scarce, and the International Water Resource Management Institute projects that by 2025, Pakistan, South Africa, and large parts of India and China will also be water scarce [5]. To put this in perspective: the U.S. would have to suffer a decrease in water supply that produces an 80 percent decrease in per capita water consumption to reach the United Nations definition of "water scarce." These projections do not factor in climate change, which is expected to exacerbate water problems in many areas.

IMPAIRED FOOD PRODUCTION

Access to vital resources, primarily food and water, can be an additional causative factor of conflicts, a number of which are playing out today in Africa. Probably the best known is the conflict in Darfur between herders and farmers. Long periods of drought resulted in the loss of both farmland and grazing land to the desert. The failure of their grazing lands compelled the nomads to migrate southward in search of water and herding ground, and that in turn led to conflict with the farming tribes occupying those lands. Coupled with population growth, tribal, ethnic, and religious differences, the competition for land turned violent. Probably more than any other recent conflict, Darfur provides a case study of how existing marginal situations can be exacerbated beyond the tipping point by climate-related factors. It also shows how lack of essential resources threatens not only individuals and their communities but also the region and the international community at large.

In some areas of the Middle East, tensions over water already exist.

Worldwide food production will be affected by climate change in a variety of ways. Crop ecologists estimate that for every 1.8°F rise in temperature above historical norms, grain production will drop 10 percent [6].

Most of the world's growth in food demand is occurring on the Indian subcontinent and in sub-Saharan Africa, areas already facing food shortages [6]. Over the coming decades, these areas are expected to become hotter and drier [7].

HEALTH CATASTROPHES

Climate change is likely to have major implications for human health. While some impacts, such as reduced deaths from cold temperatures in some areas, will be positive, the World Health Organization estimates that the overall impact will be negative [8].

The major concern is significant spreading of the conditions for vector-borne diseases, such as dengue fever and malaria, and food-borne diseases, such as salmonellosis [8]. The decline in available fresh water in some regions will also have an impact, as good health and adequate supplies of clean water are inextricably linked.

A health emergency involving large numbers of casualties and deaths from disease can quickly expand into a major regional or global security challenge that may require military support, ranging from distribution of vaccines to full-scale stability operations [9].

LAND LOSS AND FLOODING: DISPLACEMENT OF MAJOR POPULATIONS

About two-thirds of the world's population lives near coastlines [10], where critically important facilities and infrastructure, such as transportation routes, industrial facilities, port facilities, and energy production and distribution facilities are located. A rise in sea level means potential loss of land and displacement of large numbers of people. Even in our own nation, Hurricane Katrina showed the social upheaval and tensions that can result from land loss and displaced populations. But while the impact of inundation from one-time occurrences such as Hurricane Katrina is temporary, even as it is devastating, inundation from climate change is likely to be permanent on the scale of human lifetimes. Rising sea levels will also make coastal areas more vulnerable to flooding and land loss through erosion.

Storm surges will also take a greater toll on coastal communities and infrastructure as sea levels rise. According to a Pacific Institute study, a six-inch rise in the water level of San Francisco Bay would mean a fairly routine one-in-ten-year storm would wreak as much damage as a far more serious "hundred-year storm" would have caused before the sea level rise [11]. In the U.S., we may be able to cope with such a change, but poorer nations would be greatly challenged.

Most of the economically important major rivers and river deltas in the world—the Niger, the Mekong, the Yangtze, the Ganges, the Nile, the Rhine, and the Mississippi—are densely populated along their banks. As sea levels rise and storm surges increase, saline water can contaminate groundwater, inundate river deltas and valleys, and destroy croplands.

SECURITY CONSEQUENCES OF THESE DESTABILIZING EFFECTS

GREATER POTENTIAL FOR FAILED STATES AND THE GROWTH OF TERRORISM

Many developing countries do not have the government and social infrastructures in place to cope with the types of stressors that could be brought on by global climate change.

When a government can no longer deliver services to its people, ensure domestic order, and protect the nation's borders from invasion, conditions are ripe for turmoil, extremism and terrorism to fill the vacuum. Lebanon's experience with the terrorist group Hezbollah and the Brazilian government's attempts to reign in the slum gang First Capital Command [12] are both examples of how the central governments' inability to provide basic services has led to strengthening of these extra-governmental entities.

MASS MIGRATIONS ADD TO GLOBAL TENSIONS

The reasons for mass migrations are very complex. However, when water or food supplies shift or when conditions otherwise deteriorate (as from sea level rise, for example), people will likely move to find more favorable conditions [13]. Although climate change may force migrations of workers due to economic conditions, the greatest concern will be movement of asylum seekers and refugees who due to ecological devastation become settlers:

- By 2025, 40 percent of the world's population will be living in countries experiencing significant water shortages [14].
- Over the course of this century, sea level rise could potentially cause the displacement of tens of millions of people from low-lying areas such as Bangladesh [15].

Migrations in themselves do not necessarily have negative effects, although taken in the context of global climate change a net benefit is highly unlikely. Three types of migration patterns occur.

VOICES OF EXPERIENCE

ADMIRAL T. JOSEPH LOPEZ, USN (Ret.)

Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

ON CLIMATE CHANGE AND THE CONDITIONS FOR TERRORISM

Some Americans believe we don't need to worry about climate change for decades. They say the issue isn't as urgent as the war on terror. Adm. Lopez, the retired top NATO commander in Bosnia, has a different take. He sees a strong connection between the two.

"Climate change will provide the conditions that will extend the war on terror," Adm. Lopez said.

"You have very real changes in natural systems that are most likely to happen in regions of the world that are already fertile ground for extremism," Adm. Lopez said. "Droughts, violent weather, ruined agricultural lands—those are the kinds of stresses we'll see more of under climate change."

Those changes in nature will lead to changes in society. "More poverty, more forced migrations, higher unemployment. Those conditions are ripe for extremists and terrorists."

In the controversial war on terrorism, Adm. Lopez noted, there is general agreement on at least one thing: It's best to stop terrorism before it develops. "In the long term, we want to address the underlying conditions that terrorists seek to exploit. That's what we'd like to do, and it's a consensus issue—we all want to do that. But climate change prolongs those conditions. It makes them worse."

"Dealing with instability and how you mitigate that leads to questions about the role U.S. security forces can play," Adm. Lopez added. "What can we do to alleviate the problems of instability in advance? And keep in mind this will all be under a challenged resource situation. This is very complicated. Of course, the military can be a catalyst for making this happen, but it can't do it all. This is also about economics, politics, and diplomacy.

"In the military, we've often run into problems associated with what we call 'stovepipes,' where each branch of the service has its own way of doing things. And we've learned that stovepipes don't work well. We have to take the same approach with our government, to ensure that the many agencies are working together. In those cases where we do get involved, the task should not automatically be the responsibility of the U.S. military."

He also described other layers of complexity. Even in those cases where the U.S. may choose to embrace such a role, the best solutions may require a nongovernmental component. "If you don't include economists or far-thinking, out-of-the-box business people in this, you'll get shortchanged." He also said the U.S. "can't imply that we'll do this all alone. We need to make sure we don't give that impression. The same forces of economics, business, politics, diplomacy, and military and security interests can function to build coalitions in order to maintain stability when challenged by dramatic climate change."

"Climate change will provide the conditions that will extend the war on terror."

The greatest concern will be movement of asylum seekers and refugees who due to ecological devastation become settlers...

Some migrations take place within countries, adding to a nation's political stress, causing economic upheaval—positive and negative—and distracting from other issues. As a developed nation, the U.S. was able to absorb the displacement of people from the Gulf Coast in the wake of Hurricane Katrina without suffering economic or political collapse, but not without considerable turmoil.

Some migrations cross international borders. Environmental degradation can fuel migrations in less developed countries, and these migrations can lead to international political conflict. For example, the large migration from Bangladesh to India in the second half of the last century was due largely to loss of arable land, among other environmental factors. This affected the economy and political situation in the regions of India that absorbed most of this population shift and resulted in violence between natives and migrants [16].

A third form of migration involves not only crossing international borders but moving across vast regions while doing so. Since the 1960s, Europe has experienced this kind of "south to north" migration, with an influx of immigrants from Africa and Asia. The shift in demographics has created racial and religious tensions in many European countries, as evidenced in the 2005 civil unrest in France.

POTENTIAL ESCALATION OF CONFLICTS OVER RESOURCES

To live in stability, human societies need access to certain fundamental resources, the most important of which are water and food. The lack, or mismanagement, of these resources can undercut the stability of local populations; it can affect regions on a national or international scale.

Disputes over key resources such as water do not automatically trigger violent outcomes, and no recent wars have been waged solely over water resources. In areas with a strong government and societal cohesiveness, even tense disputes and resource crises can be peacefully overcome. In fact, in recent years, arguments have been made that multinational cooperation over precious water resources has been more an instrument of regional peace than of war [17].

Nevertheless, resource scarcity always has the potential to be a contributing factor to conflict and instability in areas with weak and weakly supported governments [19]. In addition, there is always the potential for regional fighting to spread to a national or international scale. Some recent examples include: the 1994 genocide in Rwanda that was furthered by violence over agricultural resources; the situation in Darfur, Sudan, which had land resources at its root and which is increasingly spilling over into neighboring Chad; the 1970s downfall of Ethiopian Emperor Haile Selassie through his government's inability to respond to food shortages; and the 1974 Nigerian coup that resulted largely from an insufficient response to famine [19].

Whether resource scarcity proves to be the impetus for peaceful cooperation or an instigator of conflict in the future remains to be seen. Regions that are already water scarce (such as Kuwait, Jordan, Israel, Rwanda, Somalia, Algeria, and Kenya) may be forced to confront this choice as climate change exacerbates their water scarcity.

REGIONAL IMPACTS OF CLIMATE CHANGE

AFRICA

VULNERABLE TO CLIMATE CHANGE IMPACTS

Africa's importance to U.S. national security can no longer be ignored. Indeed, with the recent establishment of a U.S. African Command, the U.S. has underscored Africa's strategic importance. Its weak governments and the rising presence of terrorist groups make Africa important to the fight against terrorism. Moreover, Africa is also of strategic value to the U.S. as a supplier of energy; by 2015, it will supply 25 to 40 percent of our oil, and it will also be a supplier of strategic minerals such as chrome, platinum, and manganese.

Such changes will add significantly to existing tensions and can facilitate weakened governance, economic collapses, massive human migrations, and potential conflicts.

Reductions in soil moisture and further loss of arable land may be the most significant of the projected impacts of climate change in Africa. At the same time, extreme weather events are likely to increase. These expected changes portend reduced supplies of potable water and food production in key areas. Such changes will add significantly to existing tensions and can facilitate weakened governance, economic collapses, massive human migrations, and potential conflicts. In Somalia, for example, alternating droughts and floods led to migrations of varying size and speed and prolonged the instability on which warlords capitalized.

Increased political instability in Africa potentially adds additional security requirements for the U.S. in a number of ways. Stability operations, ranging from humanitarian direct delivery of goods and the protection of relief workers, to the establishment of a stable and reconstructed state, can place heavy demands on the U.S. military. While the nature of future stability operations is a matter of speculation, historically some stability operations have involved significant military operations and casualties. Political instability also makes access to African trade and resources, on which the U.S. is reliant for both military and civilian uses, a riskier proposition.

UNSTABLE GOVERNMENTS AND TERRORIST HAVENS

Africa is increasingly crucial in the ongoing battle against civil strife, genocide, and terrorism. Numerous African countries and regions already suffer from varying degrees of famine and civil strife. Darfur, Ethiopia, Eritrea, Somalia, Angola, Nigeria, Cameroon, Western Sahara—all have been hit hard by tensions that can be traced in part to environmental causes. Struggles that appear to be tribal, sectarian, or nationalist in nature are often triggered by reduced water supplies or reductions in agricultural productivity.

The challenges Africa will face as a result of climate change may be massive, and could present serious threats to even the most stable of governments. Many African nations can

GENERAL CHARLES F. "CHUCK" WALD, USAF (Ret.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM)

ON CLIMATE CHANGE IN AFRICA

When asked why Americans should be interested in African security issues, retired Air Force Gen. Chuck Wald gave a number of reasons.

"We ought to care about Africa because we're a good country," Gen. Wald said. "We have a humanitarian character; it's one of our great strengths, and we shouldn't deny it. Some may be tempted to avert their eyes, but I would hope we instead see the very real human suffering taking place there. We should be moved by it, challenged by it. Even in the context of security discussions, I think these reasons matter, because part of our security depends on remaining true to our values.

"There are exotic minerals found only in Africa that have essential military and civilian uses," Gen. Wald continued. "We import more oil from Africa than the Middle East—probably a shock to a lot of people—and that share will grow. Africa could become a major exporter of food.

"My view is that we'll be drawn into the politics of Africa, to a much greater extent than in the past. A lot of Americans today would say Africa is an optional engagement. I don't think that's the case, even today, but it certainly won't be in the future."

To show how climate change can worsen conditions that are already quite desperate, Gen. Wald described a trip to Nigeria.

"We landed in Lagos late in the afternoon," Gen. Wald said. "This is a city, now, with roughly 17 million people. The best way to describe our drive from the airport to the hotel is that it reminded me of a 'Mad Max' movie. There were massive numbers of people on the roads, just milling around. There were huge piles of trash. There were fires along the roadside and in the distance—huge fires. It was just short of anarchy.

"That's the situation today. Even in a time of relative stability, there is very little civil governance, and very little ability to serve huge numbers of people with basics like electricity, clean water, health care, or education.

"If you add rising coastal waters and more extreme weather events, you then have millions of people who could be displaced. There really is no controlled place for them to go, no capacity for an organized departure, and no capacity to make new living situations. When you add in the effects of climate change, it adds to the

"My view is that we'll be drawn into the politics of Africa, to a much greater extent than we have in the past."

existing confusion and desperation, and puts more pressure on the Nigerian government. It makes the possibility of conflict very real. If the delta is flooded, or if major storms damage their drilling capacity, you lose the primary source of income.

"Culturally, you have a country that is split geographically between Muslims and Christians. If migrations occur, you put real pressure on that country. It's already tense and fragile. When you exacerbate that situation with climate change effects, it's not hard to postulate on the dangers."

best be described as failed states, and many African regions are largely ungoverned by civil institutions. When the conditions for failed states increase—as they most likely will over the coming decades—the chaos that results can be an incubator of civil strife, genocide, and the growth of terrorism.

LESS EFFECTIVE GOVERNANCE AND POTENTIAL MIGRATIONS

More than 30 percent of the world's refugees and displaced persons are African. Within the last decade, severe food shortages affected twenty-five African countries and placed as many as 200 million people "on the verge of calamity" [20].

Expected future climate change will exacerbate this problem. The Sahara desert is spreading [21], and the sub-Saharan region is expected to suffer reduced precipitation [22]. As climate changes and agricultural patterns are disrupted, the geopolitics of the future will increasingly be the politics of scarcity. Potential

...the chaos that results can be an incubator of civil strife, genocide, and the growth of terrorism.

rainfall decreases in North Africa would likely exacerbate the problem of migration to Europe. Reduced rainfall and increasing desertification of the sub-Saharan region will likely also result in migrations to Europe, as well as migrations within the African continent.

LAND LOSS AND WEATHER DISASTERS

Sea level rise could also result in the displacement of large numbers of people on the African continent, as more than 25 percent of the African population lives within 100 kilometers (sixty-two miles) of the coast, and six of Africa's ten largest cities are on the coast. Nigeria and Mozambique are particularly vulnerable to the effects of sea level rise and storm surges. Two cyclones in 2000 displaced 500,000 people in Mozambique and caused 950,000 people to require some form of humanitarian assistance [23]. The Niger Delta accounts for about 7.5 percent of Nigeria's land area and a population of 20 million people.

In light of the potential magnitude of the human crisis that could result from major weather-related natural disasters and the magnitude of the response and recovery efforts that would be required, stability operations carried out by international militaries will likely occur more frequently.

HEALTH CHALLENGES WILL CONTINUE TO ESCALATE

Severe and widespread continental health issues complicate an already extremely volatile environment. Climate change will have both direct and indirect impacts on many diseases endemic to Africa such as malaria and dengue fever [24]. Increases in temperature can expand the latitude and altitude ranges for malaria, and flooding from sea level rise or severe weather events can increase the population of malaria vectors. For example, a temperature rise of 2°F can bring a malaria epidemic to Kenya. Excessive flooding is also conducive to the spread of cholera.

VOICES OF EXPERIENCE

VICE ADMIRAL PAUL G. GAFFNEY II, USN (Ret.)

Former President, National Defense University; Former Chief of Naval Research and Commander, Navy Meteorology and Oceanography Command

ON MILITARY RESEARCH AND CLIMATE SCIENCE

The Department of Defense and the intelligence community have in the past used their immense capability for data collection and analysis to address national and international environmental questions. Retired Vice Adm. Paul G. Gaffney II says we have the capacity to do this again, this time for better understanding and monitoring of climate change.

The DoD offers equipment, talent and, as Adm. Gaffney put it, "Data, data, data."

"You will find the defense and intelligence communities have extraordinary amounts of data, and, if done in a careful and deliberate manner, data collected in the past and into the future can be made available to climate scientists," Adm. Gaffney said. "Be it imagery, other satellite records, data from Navy oceanographic ships and vehicles, surface warships and submarines, or observations collected by aircraft—you can find ways to smooth it to protect what must be protected if the raw data cannot be released. If climate change is, in fact, a critical issue for security, then the military and intelligence communities should be specifically tasked to aggressively find ways to make their data, talent, and systems capabilities available to American efforts in understanding climate change signals.

"Most of our ships are already outfitted to collect basic atmospheric and oceanic information. U.S. military platforms are all over the world, all of the time; they become platforms of opportunity to collect data for this global issue."

Adm. Gaffney also cited staff capabilities.

"The quality of personnel from the defense and intelligence organizations is exceptional," he said. "Within the DoD, we have labs that are as good as any that exist anywhere in the world, using whatever metrics you want—papers published, patents, Nobel laureates.

"Look at the Navy ocean modelers and remote sensing experts. They worked with scientists at NASA's Jet Propulsion Lab to unlock the secrets of El Niño, using space-borne altimetry data and new numerical ocean circulation models. The mission was a military one, but it ultimately played a role in helping us understand more about the climate."

Throughout the Cold War, the U.S. and the Soviet Union each collected data in the Arctic. Ice thickness and sub-ice ocean conditions affecting acoustics were critical security issues.

"The mission was a military one, but it ultimately played a role in helping us understand more about the climate."

After the breakup of the Soviet Union, many saw that that data could be used to determine temperature and ice condition changes over time. The two sides collaborated on ways to share and reconcile the data, and in 1995 released the Arctic Ocean Atlas to the world's scientific community. The data have advanced understanding of climate change in significant ways.

"I think there's another component to this," said Adm. Gaffney. "Defense employees [military and civilian] actually have a responsibility to the nation when they have a certain skill. They have a responsibility to share that with the public and the nation, as long as security is not compromised. They've done this in the past. And I'd love to see them able to do this more often in the future."

ASIA

CLIMATE CHANGE CAN AFFECT IMPORTANT U.S. STRATEGIC INTERESTS

Most climate projections indicate increasing monsoon variability, resulting in increases in both flood and drought intensity in temperate and tropical Asia [24]. Almost 40 percent of Asia's population of nearly 4 billion lives within forty-five miles of its nearly 130,000-mile-long coastline. Sea level rise, water availability affecting agricultural productivity, and increased effects of infectious disease are the primary climate effects expected to cause problems in Asia.

SEA LEVEL RISE MAY THREATEN MILLIONS

Some of the most vulnerable regions in the world to sea level rise are in southern Asia, along the coasts of Pakistan, India, Sri Lanka, Bangladesh, and Burma; and Southeast Asia, along the coasts between Thailand and Vietnam, including Indonesia and the Philippines.

Asia, where hundreds of millions of people rely on waters from vanishing glaciers on the Tibetan plateau, could be among the hardest hit regions.

Sandy coastlines backed by densely populated, low-lying plains make the Southeast Asian region particularly vulnerable to inundation. Coastal Malaysia, Thailand, and Indonesia could all be threatened with flooding and the loss of important coastal farmlands.

The location and topography of Bangladesh make it one of the most vulnerable countries in the world to a rise in sea level. Situated at the northeastern region of South Asia on the Bay of Bengal, it is about the size of Iowa with a population of almost 150 million. It is very flat and low lying, except in the northeast and southeast regions, and has a coastline exceeding 300 miles. About 10 percent of Bangladesh is within three feet of mean sea level. Over the next century, population rise, land scarcity and frequent flooding coupled with increased storm surge and sea level rise could cause millions of people to cross the border into India. Migration across the border with India is already such a concern that India is building a fence to keep Bangladeshis out.

India and Pakistan have long, densely populated and low-lying coastlines that are very vulnerable to sea level rise and storm surge. Coastal agriculture, infrastructure, and onshore oil exploration are at risk. Possible increases in the frequency and intensity of storm surges could be disproportionately large in heavily developed coastal areas and also in low-income rural areas, particularly such low-lying cities such as Mumbai, Dhaka and Karachi.

WATER STRESS AFFECTS ASIA'S ABILITY TO FEED ITS PEOPLE

By 2050, regions dependent on glacial melting for water may face serious consequences. Asia, where hundreds of millions of people rely on waters from vanishing glaciers on the Tibetan plateau, could be among the hardest hit regions.

Climate change has the potential to exacerbate water resource stresses in most regions of Asia [7]. Most countries in Asia will experience

VOICES OF EXPERIENCE

ADMIRAL JOSEPH W. PRUEHER, USN (Ret.)

Former Commander-in-Chief of the U.S. Pacific Command (PACOM) and Former U.S. Ambassador to China

ON CLIMATE CHANGE IN THE PACIFIC

In a discussion of climate change issues in the Pacific region, retired Adm. Joseph Prueher first considered the issue from a singular perspective: the impact climate change may have on the region's governments and their relative stability.

Using Singapore as an example, he said, "It's a democracy, but with a very strong leadership. They've prospered, but owing to lack of space they have many restrictions we do not have. If one looks ahead to the effects of climate change, you start with the understanding that Singapore, low lying and very hot, will face more storms and more moisture. It will face coastal impacts. Those kinds of changes, in a crowded nation, create a whole set of issues that affect not just the economy and culture, but the security dynamic as well."

Adm. Prueher then shifted the conversation to the region's governments in general.

"It may well be that in very crowded nations, a stronger government is necessary in order to avoid instability," he said. "In Asia, one sees a whole line of countries with governments exercising very firm control. But when you look to the future to consider the kinds of impacts we may see—flooding, extreme weather events, real disruptions—you also have to consider some steps that we in the U.S. would think offensive. Those are steps these governments may feel they need to take in order to avoid chaos."

Referencing low-lying regions where arable land will be lost, he said, "You see mass destruction in countries where the government is not robust. When people can't cope, governing structures break down."

Adm. Prueher noted that how a government responds presents a new set of issues for American political and military leaders.

"Most of our security forces are for protecting our nation from outside, but that's not necessarily the case in the rest of the world," Adm. Prueher said. "Military personnel elsewhere are often directed internally. They focus on keeping internal order. There might be cases where the U.S. military might be in a position to help deal with the effects of climate change—with floods or the migrations that might result from them. The immediate goal would be to relieve suffering, not to preserve governments. But if you're partnering with a nation's army keeping domestic order, that can be a real challenge."

When asked about China, Adm. Prueher noted that the European Union is working to identify ways of cooperating with the Chinese on the development of clean coal technologies. And he cautioned against those in the U.S. who oppose any kind of technology exchange with China.

"Yes, China is focused heavily on growth. Yes, there is what I think is a quite remote possibility of future military conflict. And, yes, it is a real challenge to negotiate with them; one can count on them to negotiate toward what they perceive to be their own national interest," he said. "Reasonable enough. But on the issue of carbon emissions, it doesn't help us to solve our problem if China doesn't solve theirs. And that means we need to engage them on many fronts. Issues of great importance to our world will not get solved without U.S.-Chinese cooperation. I happen to like dealing with the Chinese. You may not, or you may be suspicious of them, but we need to cooperate.

"They have 1.3 billion people, 200 million of whom are under-employed or unemployed," Adm. Prueher said. "They have a great deal of pride and see themselves as a great nation. Most of what we say to enhance environmental progress in China is seen by them as a way to stop them from continuing economic growth.

"Not talking to the Chinese is not an option."

VOICES OF EXPERIENCE

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (Ret.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

ON CLIMATE, ENERGY AND BATTLEFIELD READINESS

Retired Air Force Lt. Gen. Larry Farrell sees a great deal of uncertainty about climate change and appears willing to engage any credible scientist in discussions of discrepancies among climate models.

"You might say I'm from Missouri on this issue—you have to show me," he said. "And there is still much uncertainty and debate on this issue." Despite this, Gen. Farrell sees indications that some change is occurring.

"Clearly, there has been some warming over the past 100 years and some climate change. These changes have been accompanied by fairly significant increases in the greenhouse gases carbon dioxide and methane. If there is a connection between warming trends and greenhouse gases, our use of energy may be playing a part in this. If these trends continue into the future, the changes could well exacerbate existing social and political instabilities and create new ones. The military has the obligation to assess the potential military implications of these trends." Gen. Farrell's preference is to focus on solutions.

"If you advocate intelligent energy solutions, you'll solve this problem," Gen. Farrell said, before walking through a long list of reasons for a focus on energy.

A key concern for Gen. Farrell: battlefield readiness.

"Seventy percent of the tonnage on the battlefield is fuel," he said. "That's an amazing number. Between fuel and water, it's almost everything we take to the battlefield. Food and ammo are really quite small in comparison.

"Delivering that fuel requires secure lines of communication," Gen. Farrell said. "If you have bases nearby, you may be able to deliver it with much less risk, but that's a supply line issue. And we see in Iraq how dangerous it can be to transport fuel.

"The military should be interested in fuel economy on the battlefield," he said. "It's a readiness issue. If you can move your men and materiel more quickly, if you have less tonnage but the same level of protection and firepower, you're more efficient on the battlefield. That's a life and death issue."

Gen. Farrell talked about the challenge of focusing on long-term issues.

"Climate change is not something people can recognize," he said. "In geologic times, it's quick. But in human terms, it's still very slow. It's hard to get all of us to do something about it. And that leads me to believe we should deal with other things that are a problem today but that also get us to the heart of climate change. That's where I get to the issue of smart energy choices.

"Focus on conservation and on energy sources that aren't based in carbon. Move toward a hydrogen economy, in part because you know it will ultimately give you efficiency and, yes, profit. When you pursue these things, you build alliances along the way. That's safety. It's a benefit we see right now."

He suggested another reason as well: There are military impacts that come from our energy use.

"We're forced to be interested in parts of the world because of our energy consumption," he said. "Solving the energy problem solves a real security problem. You get to choose your points of engagement. It's like one of the things your grandmother told you. 'Don't go looking for trouble. If you find trouble, you have to deal with it—but don't go looking for it!' Well, when we go looking for oil, we're really looking for trouble."

substantial declines in agricultural productivity because of higher temperatures and more variable rainfall patterns [25]. Net cereal production in South Asia, for example, is projected to decline by 4 to 10 percent by the end of this century under the most conservative climate change projections.

But the problem isn't just water scarcity—too much water can also be a problem. By 2050, snow melting in the high Himalayas and increased precipitation across northern India are likely to produce flooding, especially in catchments on the western side of the Himalayas, in northern India, Nepal, Bangladesh, and Pakistan.

RISING SPREAD OF INFECTIOUS DISEASE

Climate change is expected to increase the geographic range of infectious diseases such as malaria, dengue fever, and schistosomiasis and increase the risk of water-borne disease. Climate projections indicate the Asia/Pacific region as a whole is likely to become warmer and wetter in the coming decades, creating conditions more conducive to disease vectors such as mosquitoes. With the exception of east central China and the highlands of west China, much of the Asia/Pacific region is exposed to malaria and dengue or has conditions suitable for their spread. This region will continue to be a hot spot for these diseases in the decades ahead, with certain regions becoming more prone to epidemics.

EUROPE

THREATENED BY CLIMATE PROBLEMS FROM OTHER PARTS OF THE WORLD

Europe is getting warmer overall, northern Europe is getting wetter, and southern Europe is getting drier. (For the purposes of this report, Europe includes the western part of the former Soviet Union.)

The developed nations of Europe will likely be able to deal with the direct climate changes expected for that region, but some of the less developed nations (the Balkans, for instance) might be stressed. Europe has already experienced extreme weather events that herald potential climate change effects: the more than 35,000 deaths associated with the heat wave of 2003 are a reminder of the vulnerability of all nations to climate extremes [26]. However, the major impact on Europe from global climate change is likely to be migrations, now from the Maghreb (Northern Africa) and Turkey, and increasingly, as climate conditions worsen, from Africa.

With its shortages of water, the Mediterranean area could experience considerable strain.

DIRECT IMPACTS: HOTTER TEMPERATURES AND RISING SEAS

Most of Europe has experienced surface air temperature increases during the twentieth century (1.44°F on average), with the largest increases over northwest Russia and the Iberian Peninsula. Temperatures in Europe since 1990 have been the warmest since records have been kept. More heat waves across all of Europe are likely to increase stress on human health and could produce an increased risk of malaria and dengue fever in southern Europe. Agricultural zones would move north, and the Mediterranean regions, especially in Spain, would suffer a greater loss of productivity.

Precipitation is expected to increase in the north but decrease in the central and eastern Mediterranean zones and south Russia, with acute water shortages projected in the Mediterranean area, especially in the summer.

MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN EUROPE

The capacity for adaptation to these changes is very high in most of prosperous, industrial Europe, but less so in lesser-developed places like the Balkans, Moldova, and the Caucasus. With its shortages of water, the Mediterranean area could experience considerable strain. In northern Europe, countries may build higher dikes, as they have done in the past, but at a certain point that may not be sufficient, and much port and other coastal infrastructure would have to be moved further inland, at great expense. Some northern migration within Europe might be expected—the Italians already face a large Albanian immigration, and others may press north from the Balkans.

THE PRIMARY STRATEGIC CONCERN OF EUROPEANS: MASSIVE MIGRATIONS TO EUROPE

The greater threat to Europe lies in migration of people from across the Mediterranean, from the Maghreb, the Middle East, and sub-Saharan Africa. Environmental stresses and climate change are certainly not the only factors driving migrations to Europe. However, as more people migrate from the Middle East because of water shortages and loss of their already marginal agricultural lands (as, for instance, if the Nile Delta disappears under the rising sea level), the social and economic stress on European nations will rise.

It is possible that Europeans, given their long and proximate association with the sub-Saharan African countries, may undertake more stability operations, as they have in Sierra Leone and Côte d'Ivoire. Their militaries, and in particular their navies and coast guards, would also have to increase their activities in securing their borders and in intercepting migrants moving by sea, as is now going on through the Canary Islands.

MIDDLE EAST

ABUNDANT OIL, SCARCE WATER AND INTERNATIONAL CONFLICT

The Middle East has always been associated with two natural resources, oil (because of its abundance) and water (because of its scarcity). The Persian Gulf contains more than half (57 percent) of the world's oil reserves, and about 45 percent of the world's natural gas reserves. And because its production costs are among the world's lowest, the Persian Gulf region is likely to remain the world's largest oil exporter for the foreseeable future. At the end of 2003, Persian Gulf countries produced about 32 percent of the world's oil. Because of its enormous oil endowment, the Middle East is one of the most strategically significant regions of the world. The security impacts of climate change on the Middle East are greatly magnified by its historical and current levels of international conflict, and competition for increasingly scarce resources may exacerbate the level of conflict. This is the region of the world in which the U.S. is most engaged militarily.

WATER: INCREASING STRESS ON AN EXISTING SHORTAGE

In this region, water resources are a critical issue; throughout history, cultures here have flourished around particular water sources. With the population explosion underway, water will become even more critical. Of the countries in the Middle East, only Egypt, Iran, and Turkey have abundant fresh water resources. Roughly two-thirds of the Arab world depends on sources outside their borders for water. The most direct effect of climate change to be felt in the Middle East will be a reduction in precipitation. But the change will not be uniform across the region.

The flows of the Jordan and Yarmuk rivers are likely to be reduced, leading to significant water stress in Israel and Jordan, where water demand already exceeds supply. Exacerbation of water shortages in those two countries and in Oman, Egypt, Iran, and Iraq are likely to threaten conventional crop production, and salinization of coastal aquifers could further threaten agriculture in those regions.

SEA LEVEL RISE

Sea level rise combined with increased water demand from growing populations are likely to exacerbate saltwater intrusion into coastal fresh water aquifers, already a considerable problem for the Gaza Strip. Salinization of coastal aquifers could further threaten agriculture in these regions. Additional loss of arable land and decreases in food security could encourage migration within the Middle East and Africa, and from the Middle East to Europe and elsewhere.

INFLAMING A REGION OF POLITICAL INSTABILITY

Climate change has the potential to exacerbate tensions over water as precipitation patterns change, declining by as much as 60 percent in some areas. In addition, the region already suffers from fragile governments and infrastructures, and as a result is susceptible to natural disasters. Overlaying this is a long history of animosity among countries and religious groups. With most of the world's oil being in the Middle East and the industrialized and industrializing nations competing for this resource, the potential for escalating tensions, economic disruption, and armed conflict is great.

VOICES OF EXPERIENCE

GENERAL ANTHONY C. "TONY" ZINNI, USMC (Ret.)

Former Commander-in-Chief of U.S. Central Command (CENTCOM)

ON CLIMATE CHANGE, INSTABILITY AND TERRORISM

A starting point in understanding this connection might be to "look at how climate change effects could drive populations to migrate," Gen. Zinni said. "Where do these people move? And what kinds of conflicts might result from their migration? You see this in Africa today with the flow of migrations. It becomes difficult for the neighboring countries. It can be a huge burden for the host country, and that burden becomes greater if the international community is overwhelmed by these occurrences.

"You may also have a population that is traumatized by an event or a change in conditions triggered by climate change," Gen. Zinni said. "If the government there is not able to cope with the effects, and if other institutions are unable to cope, then you can be faced with a collapsing state. And these end up as breeding grounds for instability, for insurgencies, for warlords. You start to see real extremism. These places act like Petri dishes for extremism and for terrorist networks."

In describing the Middle East, the former CENTCOM commander said, "The existing situation makes this place more susceptible to problems. Even small changes may have a greater impact here than they may have elsewhere. You already have great tension over water. These are cultures often built around a single source of water. So any stresses on the rivers and aquifers can be a source of conflict. If you consider land loss, the Nile Delta region is the most fertile ground in Egypt. Any losses there could cause a real problem, again because the region is already so fragile. You have mass migrations within the region, going on for many decades now, and they have been very destabilizing politically."

Gen. Zinni referenced the inevitability of climate change, with global temperatures sure to increase. But he also stressed that the intensity of those changes could be reduced if the U.S. helps lead the way to a global reduction in carbon emissions. He urged action now, even if the costs of action seem high.

> "It's not hard to make the connection between climate change and instability, or climate change and terrorism."

"We will pay for this one way or another," he said. "We will pay to reduce greenhouse gas emissions today, and we'll have to take an economic hit of some kind. Or we will pay the price later in military terms. And that will involve human lives. There will be a human toll.

"There is no way out of this that does not have real costs attached to it. That has to hit home."

THE WESTERN HEMISPHERE

RISKS FOR THE UNITED STATES AND OUR NEIGHBORS

Latin America includes some very poor nations in Central America and in the Caribbean, and their ability to cope with a changing climate will present challenges for them and thus for the U.S. Global climate change can lead to greater intensity of hurricanes as sea surface temperatures rise, with enormous implications for the southeastern U.S., Central America, and Caribbean nations. Loss of glaciers will strain water supply in several areas, particularly Peru and Venezuela. Rising sea levels will threaten all coastal nations. Caribbean nations are especially vulnerable in this regard, with the combination of rising sea levels and increased hurricane activity potentially devastating to some island nations.

The primary security threats to the U.S. arise from the potential demand for humanitarian aid and a likely increase in immigration from neighbor states. It is important to remember that the U.S. will be dealing with its own climate change issues at the same time.

INCREASING WATER SCARCITY AND GLACIAL MELT

The melting of glaciers at an accelerated rate in Venezuela and the Peruvian Andes is a particular concern because of the direct reliance on these glaciers for water supplies and hydroelectric power. The Peruvian plains, northeast Brazil, and Mexico, already subject to drought, will find that droughts in the future will last longer. That would lead to further land degradation and loss of food production—a blow to Latin America, which is particularly dependent on food production for subsistence, and to Brazil, whose economy is fueled by food exports.

Drought and decreased rainfall is projected to also affect the central southern U.S. That could have significant impact on food production and sources of water for millions. The High Plains (or "Ogallala") aquifer underlies much of the semi-arid west-central U.S. The aquifer provides water for 27 percent of the irrigated land in the country and supplies about 30 percent of the groundwater used for irrigation. In fact, three of the top grain-producing states—Texas, Kansas, and Nebraska—each get 70 to 90 percent of their irrigation water from the Ogallala aquifer [27]. Human-induced stresses on this groundwater have resulted in water-table declines greater than 100 feet in some areas [28]. This already difficult situation could be greatly exacerbated by a decrease in rainfall predicted for the region. Similarly, a recent study by the National Research Council on the Colorado River basin (the river is the main water source for tens of millions of people in the Southwest) predicted substantial decreases in river flow based on higher population coupled with the climate change affects [29].

STORMS AND SEA LEVEL RISE

In looking at the relationship between warmer temperatures and storm intensity, a panel convened by the World Meteorological Organization concluded: "It is likely that some increase in tropical cyclone peak wind-speed and rainfall

ADMIRAL DONALD L. "DON" PILLING, USN (Ret.)

Former Vice Chief of Naval Operations

ON OPERATIONAL CHALLENGES OF CLIMATE CHANGE

Retired Adm. Donald L. Pilling, former vice chief of naval operations, highlighted one of the reasons government agencies have been slow to respond to the issue of climate change.

"One of the problems in talking about this issue is that no one can give you a date by which many of the worst effects will be occurring," Adm. Pilling said. "If it's 2050, there isn't a guy in uniform today who will be wearing a uniform then. The Pentagon talks about future year plans that are six years down the road."

Still, Adm. Pilling was able to talk about the issue and the planning challenges it might offer. He enumerated a list of operational impacts, starting with the assumption that there would be increased instances of large migrations—people fleeing homelands that have felt the impacts of climate changes.

"This is key because it's easy to see how our allies can be consumed by this," Adm. Pilling said. "They won't have time to participate in exercises at sea because all of their assets will be focused on protecting the border and beaches. Europe will be focused on its own borders. There is potential for fracturing some very strong alliances based on migrations and the lack of control over borders.

"Open seas at the Arctic means you have another side of this continent exposed," he said. "Between the Canadians and us, there are a handful of ships oriented for the northernmost latitudes. But there is not much flexibility or depth there."

He said that an increase in the frequency or intensity of hurricanes could have a destabilizing effect on maintenance and the stability of ships and fleets. "It may cause you to move ships north to avoid hurricanes. If a ship's captain thinks he's in the middle of hurricane season, he's going to go out—get away from port. It impacts maintenance schedules and impacts operational structures. And that doesn't factor in the damage that hurricanes can do to our ports and maintenance facilities. We spent a few billion to restore Pascagoula after Hurricane Katrina—and we're not done yet. But at least that's an impact you can see. People can get their hands around that."

> "There is potential for fracturing some very strong alliances based on migrations and the lack of control over borders."

Over time, some of the operational issues related to climate change would be increasingly difficult to resolve.

"At headquarters, they would need to be much more thoughtful about investment decisions," he said. "Why invest significant resources in bases that are in low-lying regions? Why invest in bases that may continue to be flooded? Those are tough questions to ask, but I'd ask them."

will occur if the climate continues to warm. Model studies and theory project a 3-5% increase in wind-speed per degree Celsius increase of tropical sea surface temperatures" [30]. Warming seas and their link to storm energy are especially worrisome for Central American and small Caribbean island nations that do not have the social infrastructure to deal with natural disasters.

Flooding could increase with sea level rises, especially in the low-lying areas of North America—inundation models from the University of Arizona project that a sea level rise of three feet would cause much of Miami, Fort Myers, a large portion of the Everglades, and all of the Florida Keys to disappear [31].

In the past, U.S. military forces have responded to natural disasters, and are likely to continue doing so in the foreseeable future [32]. The military was deployed to Central America after Hurricane Mitch in 1998 and to Haiti following the rains and mudslides of 2004. The U.S. military was also heavily involved in the response to Hurricane Katrina. Climate change will likely increase calls for this type of mission in the Americas in the future.

INCREASED MIGRATION/REFUGEE FLOWS INTO THE U.S.

The greater problem for the U.S. may be an increased flow of migrants northward into the U.S. Already, a large volume of south to north migration in the Americas is straining some states and is the subject of national debate. The migration is now largely driven by economics and political instability. The rate of immigration from Mexico to the U.S. is likely to rise because the water situation in Mexico is already marginal and could worsen with less rainfall and more droughts. Increases in weather disasters, such as hurricanes elsewhere, will also stimulate migrations to the U.S. [32].

VOICES OF EXPERIENCE

GENERAL PAUL J. KERN, USA (Ret.)

Former Commanding General, U.S. Army Materiel Command

ON WEATHER, LOGISTICS, AND THE CAUSES OF WAR

In 1989, Gen. Kern commanded a brigade based at Fort Stewart, Georgia, and was preparing to send men and materiel to Turkey in advance of NATO training exercises. Those plans were interrupted by Hurricane Hugo, which appeared headed to Savannah, the port of departure for the mission.

"We were all ready to go, but the ships involved in transport had to be sent to Norfolk," Gen. Kern said. "So we broke down the shipments that had already been assembled for delivery. We then moved our aviation assets out, and moved base families into shelters. Ultimately, the hurricane hit Charleston, and did major damage to the airbase there. That meant one of my military battalions was deployed to Charleston to help with the recovery there."

"These weren't immense challenges for us—they were things we could handle," Gen. Kern said. "But the planned training exercises—preparing us for our core military mission—were not as good as they could have been. It's a very subtle thing, but there you have it in a nutshell: Extreme weather can affect your readiness."

Looking ahead, Gen. Kern, now retired from active duty, discussed wider global trends that the military must address to achieve an optimal state of readiness. He believes "the critical factors for economic and security stability in the twenty-first century are energy, water, and the environment. These three factors need to be balanced for people to achieve a reasonable quality of life. When they are not in balance, people live in poverty, suffer high death rates, or move toward armed conflict."

The need for water illustrates the consequences of imbalance. "When water is scarce, people move until they can find adequate supply," he said. "As climate change causes shifts in accessibility to water, we observe large movements of refugees and emigration."

He said Africa offers prime examples of this, and referenced a passage from the book Transboundary Rivers, Sovereignty and Development (Anthony Turton, Peter Ashton, and Eugene Cloete, eds.), which states that "there is a vast and growing literature that cites water as a likely cause of wars in the twenty-first century, and the 15 international basins in the Southern African Development Community (SADC) are regularly named as points of tension, second only to the arid and hostile Middle East."

He quoted from a letter written to him by Anthony Turton, a soldier in the war over the Okavong River basin, who wrote that "to serve one's country on the field of battle is truly noble, but to serve as a peace-builder is truly great." Turton also wrote that in his new role of restoring river basins, he has "found personal peace."

Gen. Kern also cited the late Nobel Laureate, Dr. Rick Smalley, of Rice University, who often lectured on the world's top 10 problems. Smalley listed energy, water, food, and the environment at the top of his list.

"While the military community has not focused on these issues, we often find ourselves responding to a crisis created by the loss of these staples, or by a conflict over claims to one or more

> "Military planning should view climate change as a threat to the balance of energy access, water supplies, and a healthy environment, and it should require a response."

of them," Gen. Kern said. "In my view, therefore, military planning should view climate change as a threat to the balance of energy access, water supplies, and a healthy environment, and it should require a response. Responding after the fact with troops—after a crisis occurs—is one kind of response. Working to delay these changes—to accommodate a balance among these staples—is, of course, another way."

DIRECT IMPACTS ON MILITARY SYSTEMS, INFRASTRUCTURE, AND OPERATIONS

DIRECT IMPACTS ON MILITARY SYSTEMS, INFRASTRUCTURE, AND OPERATIONS

Climate change will stress the U.S. military by affecting weapons systems and platforms, bases, and military operations. It also presents opportunities for constructive engagement.

WEAPONS SYSTEMS AND PLATFORMS

Operating equipment in extreme environmental conditions increases maintenance requirements—at considerable cost—and dramatically reduces the service life of the equipment. In Iraq, for instance, sandstorms have delayed or stopped operations and inflicted tremendous damage to equipment. In the future, climate change—whether hotter, drier, or wetter—will add stress to our weapons systems.

A stormier northern Atlantic would have implications for U.S. naval forces [34]. More storms and rougher seas increase transit times, contribute to equipment fatigue and hamper flight operations. Each time a hurricane approaches the U.S. East Coast, military aircraft move inland and Navy ships leave port. Warmer temperatures in the Middle East could make operations there even more difficult than they are today. A Center for Naval Analyses study showed that the rate at which U.S. carriers could launch aircraft was limited by the endurance of the flight deck crew during extremely hot weather [34].

BASES THREATENED BY RISING SEA LEVELS

During the Cold War, the U.S. established and maintained a large number of bases throughout the world. U.S. bases abroad are situated to provide a worldwide presence and maximize our ability to move aircraft and personnel. Climate change could compromise some of those bases. For example, the highest point of Diego Garcia, an atoll in the southern Indian Ocean that serves as a major logistics hub for U.S. and British forces in the Middle East, is only a few feet above sea level. As sea level rises, facilities there will be lost or will have to relocated. Although the consequences to military readiness are not insurmountable, the loss of some forward bases would require longer range lift and strike capabilities and would increase the military's energy needs.

Closer to home, military bases on the eastern coast of the United States are vulnerable to hurricanes and other extreme weather events. In 1992, Hurricane Andrew ravaged Homestead Air Force Base in Florida so much that it never reopened; in 2004 Hurricane Ivan knocked

Climate change—whether hotter, drier, or wetter—will add stress to our weapons systems.

out Naval Air Station Pensacola for almost a year. Increased storm activity or sea level rise caused by future climate change could threaten or destroy essential base infrastructure. If key military bases are degraded, so, too, may be the readiness of our forces.

MILITARY OPERATIONS

Severe weather has a direct effect on military readiness. Ships and aircraft operations are made more difficult; military personnel themselves must evacuate or seek shelter. As retired

Army Gen. Paul Kern explained of his time dealing with hurricanes in the U.S. Southern Command: "A major weather event becomes a distraction from your ability to focus on and execute your military mission."

In addition, U.S. forces may be required to be more engaged in stability operations in the future as climate change causes more frequent weather disasters such as hurricanes, flash floods, and extended droughts.

THE ARCTIC: A REGION OF PARTICULAR CONCERN

A warming Arctic holds great implications for military operations. The highest levels of planetary warming observed to date have occurred in the Arctic, and projections show the high northern latitudes warming more than any other part of the earth over the coming century. The Arctic, often considered to be the proverbial "canary" in the earth climate system, is showing clear signs of stress [33].

The U.S. Navy is concerned about the retreat and thinning of the ice canopy and its implications for naval operations. A 2001 Navy study concluded that an ice-free Arctic will require an "increased scope of naval operations" [35]. That increased scope of operations will require the Navy to consider weapon system effectiveness and various other factors associated with operating in this environment. Additionally, an Arctic with less sea ice could bring more competition for resources, as well as more commercial and military activity that could further threaten an already fragile ecosystem.

As extreme weather events becomes more common, so do the threats to our national electricity supply.

DEPARTMENT OF DEFENSE ENERGY SUPPLIES ARE VULNERABLE TO EXTREME WEATHER

The DoD is almost completely dependent on electricity from the national grid to power critical missions at fixed installations and on petroleum to sustain combat training and operations. Both sources of energy and their distribution systems are susceptible to damage from extreme weather.

The national electric grid is fragile and can be easily disrupted. Witness the Northeast Blackout of 2003, which was caused by trees falling onto power lines in Ohio. It affected 50 million people in eight states and Canada, took days to restore, and caused a financial loss in the United States estimated to be between $4 billion and $10 billion [36]. People lost water supplies, transportation systems, and communications systems (including Internet and cell phones). Factories shut down, and looting occurred.

As extreme weather events becomes more common, so do the threats to our national electricity supply.

One approach to securing power to DoD installations for critical missions involves a combination of aggressively applying energy efficiency technologies to reduce the critical load (more mission, less energy); deploying renewable energy sources; and "islanding" the installation from the national grid. Islanding allows power generated on the installations to flow two ways—onto the grid when there is excess production and from the grid when the load exceeds local generation. By pursuing these actions to improve resiliency of mission, DoD would become an early adopter of technologies that would help transform the grid, reduce our load, and expand the use of renewable energy.

For deployed systems, the DoD pays a high price for high fuel demand. In Iraq, significant combat forces are dedicated to moving fuel and protecting fuel supply lines. The fuel delivery situation on the ground in Iraq is so limited that that the Army has established a "Power Surety Task Force" to help commanders of forward operating bases cut the number of fuel convoys by using energy more efficiently. Maj. Gen. Richard Zilmer, USMC, commander of the multinational force in the Anbar province of Iraq, asked for help in August 2006. His request was for renewable energy systems. According to Gen. Zilmer, "reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys … 'Without this solution [renewable energy systems], personnel loss rates are likely to continue at their current rate. Continued casualty accumulation exhibits potential to jeopardize mission success….'" Along a similar vein, Lt. Gen. James Mattis, while commanding general of the First Marine Division during Operation Iraqi Freedom, urged: "Unleash us from the tether of fuel."

Energy-efficiency technologies, energy conservation practices and renewable energy sources are the tools forward bases are using to stem their fuel demand and reduce the "target signature" of their fuel convoys.

Numerous DoD studies dating from the 2001 Defense Science Board report "More Capable Warfighting Through Reduced Fuel Burden" have concluded that high fuel demand by combat forces detracts from our combat capability, makes our forces more vulnerable, diverts combat assets from offense to supply line protection, and increases operating costs. Nowhere are these problems more evident than in Iraq, where every day 2.4 million gallons of fuel is moved through dangerous territory, requiring protection by armored combat vehicles and attack helicopters [37].

DoD planners estimate that it costs $15 to deliver one gallon of fuel from its commercial supplier to the forward edge of the battlefield and about $26 to deliver a gallon of fuel from an airborne tanker, not counting the tanker aircraft cost. Furthermore, DoD's procedures for determining the types of systems it needs do not take these fuel burden considerations into account. DoD should require more efficient combat systems and should include the actual cost of delivering fuel when evaluating the advantages of investments in efficiency [38, 39].

… reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys …

DoD should have an incentive to accurately account for the cost of moving and protecting fuel and to invest in technologies that will provide combat power more efficiently. Deploying technologies that make our forces more efficient also reduces greenhouse gas emissions. The resulting technologies would make a significant contribution to the vision President Bush expressed in his State of the Union speech when he said, "America is on the verge of technological breakthroughs that will … help us to confront the serious challenge of global climate change."

Given the human and economic cost of delivering fuel to combat forces and the almost total dependence on the electric grid for critical missions, DoD has strong operational economic incentives to aggressively pursue energy efficiency in its combat systems and its installations. By investing at levels commensurate with its interests, DoD would become an early adopter of innovative technologies and could stimulate others to follow.

ENGAGEMENT OPPORTUNITIES

Climate change threats also create opportunities for constructive engagement such as stability operations and capacity building. The U.S. military helped deliver relief to the victims of the 2005 Indian Ocean tsunami because it is the only institution capable of rapidly delivering personnel and materiel anywhere in the world on relatively short notice. DoD Directive 3000.05, issued in 2006, provides the mandate to conduct military and civilian stability operations in peacetime as well as conflict to maintain order in states and regions. The Combatant Command's Theater Security Cooperation Program, which seeks to engage regional states, could be easily focused on climate change mitigation and executed in concert with other U.S. agencies through U.S. embassy country teams. The objective would be to build the host nation military's capabilities and capacity to support civilian government agencies. It also enhances good governance and promotes stability, making failed states and terrorist incursion less likely. Because many climate change problems cross borders, it could also promote regional communication and cooperation.

If the frequency of natural disasters increases with climate change, future military and political leaders may face hard choices about where and when to engage. Deploying troops affects readiness elsewhere; choosing not to may affect alliances. And providing aid in the aftermath of a catastrophic event or natural disaster can help retain stability in a nation or region, which in turn could head off U.S. military engagement in that region at a later date.

VOICES OF EXPERIENCE

ADMIRAL FRANK "SKIP" BOWMAN, USN (Ret.)

Former Director, Naval Nuclear Propulsion Program; Former Deputy Administrator-Naval Reactors, National Nuclear Security Administration

ON CLIMATE CHANGE, ENERGY, AND NATIONAL SECURITY

Adm. Bowman's more than thirty-eight years of naval service in the nuclear submarine community lead him to these thoughts: "Our nuclear submarines operate in an unforgiving environment. Our Navy has recognized this environment and has mitigated the risk of reactor and undersea operations through a combination of: a) careful selection of motivated, intelligent people whom we train and qualify to the highest standards; b) rigorous quality assurance of component design and manufacturing; c) verbatim compliance with strict rules of operation; d) routine examination of all aspects of reactor and submarine operations; and, e) a constant sharing of the lessons we learn through these processes. These components lead to a defense in depth against a very low probability, but high consequence event. We should begin planning for a similar approach in dealing with potential climate change effects on our national security."

Adm. Bowman notes that today, a raging debate is underway over a potential set of climate-induced global changes that could have a profound impact on America's national security interests. Our Military Advisory Board has heard the arguments, some depicting near-doomsday scenarios of severe weather and oceanic changes exacerbated by man-made emissions of greenhouse gases to our environment, others depicting a much less severe outcome as merely one in many observed cyclic weather patterns over time, with virtually no man-made component.

Adm. Bowman concludes that regardless of the probability of the occurrence, the projected weather-driven global events could be dire and could adversely affect our national security and military options significantly. He therefore argues that the prudent course is to begin planning, as we have in submarine operations, to develop a similar defense in depth that would reduce national security risks even if this is a low probability event, given the potential magnitude of the consequences. He feels that as the debate over cause, effect, and magnitude continues, we in the military should begin now to take action to provide a resilient defense against the effects of severe climate change, not only within our own borders, but also to provide resiliency to those regions of unrest and stress that already are threatening our national security today.

"Our nuclear submarines operate in an unforgiving environment. Our Navy has recognized this environment and has mitigated the risk. ... We should begin planning for a similar approach in dealing with potential climate change effects on our national security."

The admiral further believes that "our national security is inextricably linked to our country's energy security." Thoughtful national policy is required as we debate a correct course of future energy policy. International participation is necessary for this global issue. Adm. Bowman firmly believes that "energy and economic security—key components of our national security—must be undergirded by alternative forms of energy available indigenously and from countries whose values are not at odds with our own. As our economy and GDP have grown, so have our energy needs. This demand for energy strains available supplies; energy sources used for one purpose, such as electricity generation, are not available for other needs. Natural gas used for electricity is not available as feedstock for many industries that depend on it, like the chemical industry, the fertilizer industry, and the plastics industry. Short-term decisions made over the past decade to build cheap gas generation placed an unsustainable demand on natural gas and has resulted in hundreds of thousands of U.S. jobs moving offshore."

Adm. Bowman warns that this interdependence between energy policy and national security must be viewed over the long haul as the country addresses global climate change. "Coal and nuclear electricity generation remain the obvious choices for new U.S. generation. However, to meet the concerns over measured and measurable increases in CO_2 concentrations in our atmosphere and their potential effect on climate, the country, as a matter of national urgency, must develop the technologies to capture and sequester CO_2 from coal generation. This technology is not available today on a commercial scale, and the lead time for its development is measured in tens of years, not months.

Therefore, Adm. Bowman argues, we should begin developing plans to shore up our own defenses against the potentially serious effects of climate, regardless of the probability of that occurrence, while making more resilient those countries ill-prepared today to deal with that potential due to disease, poor sanitation, lack of clean water, insufficient electricity, and large coastal populations. In doing so, these plans must recognize the interdependency of energy and security.

WEATHER AND WARFARE

An increase in extreme weather can make the most demanding of tasks even more challenging.

Increases in global temperatures will increase the likelihood of extreme weather events, including temperature extremes, precipitation events, and intense tropical cyclone activity [7].

With this in mind, we ask the obvious: How does extreme weather affect warfare?

The impacts are significant. There are countless historical examples of how weather events have affected the outcome of a conflict.

- Typhoons (Divine Wind) twice saved Japan from invasion by Kublai Khan and his Mongol horde.
- North Sea gales badly battered the Spanish Armada in 1588 when Sir Francis Drake defeated it, saving England from invasion.

An increase in extreme weather can make the most demanding of tasks even more challenging.

- The severe and unpredictable Russian winter has defeated three invading armies: Charles XII of Sweden in 1708, Napoleon in 1812 and Hitler in 1941.
- During the American Revolution, George Washington would have been surrounded at the Battle of Long Island had adverse winds not prevented the British from landing and cutting him off.
- Hardships from a severe drought in 1788 are thought to be the spark that caused the French Revolution.
- Napoleon was defeated at the Battle of Waterloo in large part because a torrential downpour obscured visibility and delayed the French attack.

Though technology allows us to overcome many obstacles, weather still poses great threats to successful military operations on the land, sea, or in the air.

- During World War II, Typhoon Cobra capsized three destroyers, a dozen more ships were seriously damaged and 793 men died. This natural disaster, called the Navy's worst defeat in open seas in World War II, killed nearly a third as many as in the attack on Pearl Harbor.
- Many know that D-Day awaited the right weather before it began. Many don't know that a freak storm destroyed floating docks shortly beforehand, almost canceling the invasion.
- During the 1991 Persian Gulf War, heavy winds prevented Saddam Hussein from launching Scud missiles at Israel and coalition forces.
- During the Persian Gulf War and the Iraq war, sandstorms delayed or stopped operations and did tremendous damage to equipment. In March 2003, the entire invasion of Iraq was stalled for three days because of a massive sandstorm.

These examples are not meant to suggest that weather changes will put the American military at a disadvantage. They do, however, help illustrate ways in which climate change can add new layers of complexity to military operations. An increase in extreme weather can make the most demanding of tasks even more challenging.

FINDINGS AND RECOMMENDATIONS

FINDINGS AND RECOMMENDATIONS

This report is intended to advance a more rigorous national and international dialogue on the impacts of climate change on national security. We undertook this analysis for the primary purpose of presenting the problem and identifying first-order solutions. We therefore keep this list of findings and recommendations intentionally brief. We hope it will stimulate further discussion by the public and a more in-depth analysis by those whose job it is to plan for our national security.

FINDINGS

Finding 1:
Projected climate change poses a serious threat to America's national security.

Potential threats to the nation's security require careful study and prudent planning—to counter and mitigate potential detrimental outcomes. Based on the evidence presented, the Military Advisory Board concluded that it is appropriate to focus on the serious consequences to our national security that are likely from unmitigated climate change. In already-weakened states, extreme weather events, drought, flooding, sea level rise, retreating glaciers, and the rapid spread of life-threatening diseases will themselves have likely effects: increased migrations, further weakened and failed states, expanded ungoverned spaces, exacerbated underlying conditions that terrorist groups seek to exploit, and increased internal conflicts. In developed countries, these conditions threaten to disrupt economic trade and introduce new security challenges, such as increased spread of infectious disease and increased immigration.

Overall, climate change has the potential to disrupt our way of life and force changes in how we keep ourselves safe and secure by adding a new hostile and stressing factor into the national and international security environment.

Finding 2:
Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world.

Many governments in Asia, Africa, and the Middle East are already on edge in terms of their ability to provide basic needs: food, water, shelter and stability. Projected climate change will exacerbate the problems in these regions and add to the problems of effective governance. Unlike most conventional security threats that involve a single entity acting in specific ways at different points in time, climate change has the potential to result in multiple chronic conditions, occurring globally within the same time frame. Economic and environmental conditions in these already fragile areas will further erode as food production declines, diseases increase, clean water becomes increasingly scarce, and populations migrate in search of resources. Weakened and failing governments, with an already thin margin for survival, foster the conditions for internal conflict, extremism, and movement toward increased authoritarianism and radical ideologies. The U.S. may be drawn more frequently into these situations to help to provide relief, rescue, and logistics, or to stabilize conditions before conflicts arise.

Because climate change also has the potential to create natural and humanitarian disasters on a scale far beyond those we see today, its consequences will likely foster political instability where societal demands exceed the capacity of governments to cope. As a result, the U.S. may also be called upon to undertake stability and reconstruction efforts once a conflict has begun.

Finding 3:
Projected climate change will add to tensions even in stable regions of the world.

Developed nations, including the U.S. and Europe, may experience increases in immigrants and refugees as drought increases and food production declines in Africa and Latin America. Pandemic disease caused by the spread of infectious diseases and extreme weather events and natural disasters, as the U.S. experienced with Hurricane Katrina, may lead to increased domestic missions for U.S. military personnel—lowering troop availability for other missions and putting further stress on our already stretched military, including our Guard and Reserve forces.

Our current National Security Strategy, released in 2002 and updated in 2006, refers to globalization and other factors that have changed the security landscape. It cites, among other factors, "environmental destruction, whether caused by human behavior or cataclysmic mega-disasters such as floods, hurricanes, earthquakes or tsunamis. Problems of this scope may overwhelm the capacity of local authorities to respond, and may even overtax national militaries, requiring a larger international response. These challenges are not traditional national security concerns, such as the conflict of arms or ideologies. But if left unaddressed they can threaten national security."

In addition to acknowledging the national security implications of extreme weather and other environmental factors, the National Security Strategy indicates that the U.S. may have to intervene militarily, though it clearly states that dealing with the effects of these events should not be the role of the U.S. military alone.

Despite the language in our current National Security Strategy, there is insufficient planning and preparation on the operational level for future environmental impacts. However, such planning can readily be undertaken by the U.S. military in cooperation with the appropriate civilian agencies, including the State Department, the United States Agency for International Development, and the intelligence community.

Finding 4:
Climate change, national security, and energy dependence are a related set of global challenges.

As President Bush noted in his 2007 State of the Union speech, dependence on foreign oil leaves us more vulnerable to hostile regimes and terrorists, and clean domestic energy alternatives help us confront the serious challenge of global climate change. Because the issues are linked, solutions to one affect the others. Technologies that improve energy efficiency also reduce carbon intensity and carbon emissions.

RECOMMENDATIONS

Recommendation 1:
The national security consequences of climate change should be fully integrated into national security and national defense strategies.

As military leaders, we know we cannot wait for certainty. Failing to act because a warning isn't precise is unacceptable. Numerous parts of the U.S. government conduct analyses of various aspects of our national security situation covering different time frames and at varying levels of detail. These analyses should consider the consequences of climate change.

The intelligence community should incorporate climate consequences into its National Intelligence Estimate. The National Security Strategy should directly address the threat of climate change to our national security interests. It also should include an assessment of the national security risks of climate change and direct the U.S. government to take appropriate preventive efforts now.

The National Security Strategy and the National Defense Strategy should include appropriate guidance to military planners to assess risks to current and future missions of projected climate change, guidance for updating defense plans based on these assessments, and the capabilities needed to reduce future impacts. This guidance should include appropriate revisions to defense plans, including working with allies and partners, to incorporate climate mitigation strategies, capacity building, and relevant research and development.

The next Quadrennial Defense Review should examine the capabilities of the U.S. military to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events, pandemic disease events, and other missions the U.S. military may be asked to support both at home and abroad. The capability of the National Guard and Reserve to support these missions in the U.S. deserve special attention, as they are already stretched by current military operations.

The U.S. should evaluate the capacity of the military and other institutions to respond to the consequences of climate change. All levels of government—federal, state, and local—will need to be involved in these efforts to provide capacity and resiliency to respond and adapt.

Scientific agencies such as the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the United States Geologic Survey (USGS) should also be brought into the planning processes.

The defense and intelligence communities should conduct research on global climate and monitor global climate signals to understand their national security implications. Critical security-relevant knowledge about climate change has come from the partnership between environmental scientists and the defense and intelligence communities. That partnership, vibrant in the 1990s, should be revived.

Recommendation 2:
The U.S. should commit to a stronger national and international role to help stabilize climate changes at levels that will avoid significant disruption to global security and stability.

All agencies involved with climate science, treaty negotiations, energy research, economic policy, and national security should participate in an interagency process to develop a deliberate policy to reduce future risk to national security from climate change. Actions fall into two main categories: mitigating climate change to the extent possible by setting targets for long-term reductions in greenhouse gas emissions and adapting to those effects that cannot be mitigated. Since this is a global problem, it requires a global solution with multiple relevant instruments of government contributing.

While it is beyond the scope of this study to recommend specific solutions, the path to mitigating the worst security consequences of climate change involves reducing global greenhouse gas emissions. Achieving this outcome will also require cooperation and action by many agencies of government.

Recommendation 3:
The U.S. should commit to global partnerships that help less developed nations build the capacity and resiliency to better manage climate impacts.

Some of the nations predicted to be most affected by climate change are those with the least capacity to adapt or cope. This is especially true in Africa, which is becoming an increasingly important source of U.S. oil and gas imports. Already suffering tension and stress resulting from weak governance and thin margins of survival due to food and water shortages, Africa would be yet further challenged by climate change. The proposal by DoD to establish a new Africa Command reflects Africa's emerging strategic importance to the U.S., and with humanitarian catastrophes already occurring, a worsening of conditions could prompt further U.S. military engagement. As a result, the U.S. should focus on enhancing the capacity of weak African governments to better cope with societal needs and to resist the overtures of well-funded extremists to provide schools, hospitals, health care, and food.

The U.S. should target its engagement efforts, through regional military commanders and other U.S. officials, toward building capacity to mitigate destabilizing climate impacts. For example, regional commanders have routinely used such engagement tools as cooperation on disaster preparedness to help other nations develop their own ability to conduct these efforts.

Cooperative engagement has the potential to reduce the likelihood of war fighting. As Gen. Anthony C. (Tony) Zinni (Ret.) has said: "When I was commander of CENTCOM, I had two missions: engagement and war fighting: If I do engagement well, I won't have to do war fighting." The U.S. cannot do this alone: nor should the military be the sole provider of such cooperative efforts. But the U.S. can lead by working in cooperation with other nations. Such efforts promote greater regional cooperation, confidence building and the capacity of all elements of national influence to contribute to making nations resilient to the impacts of climate change.

Recommendation 4:
The Department of Defense should enhance its operational capability by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power through energy efficiency.

DoD should require more efficient combat systems and should include the actual cost of delivering fuel when evaluating the advantages of investments in efficiency. Numerous DoD studies dating from the 2001 Defense Science Board report "More Capable Warfighting Through Reduced Fuel Burden" have concluded that high fuel demand by combat forces detracts from our combat capability, makes our forces more vulnerable, diverts combat assets from offense to supply line protection, and increases operating costs. Nowhere are these problems more evident than in Iraq, where every day 2.4 million gallons of fuel is moved through dangerous territory, requiring protection by armored combat vehicles and attack helicopters.

Deploying technologies that make our forces more efficient also reduces greenhouse gas emissions. DoD should invest in technologies that will provide combat power more efficiently. The resulting technologies would make a significant contribution to the vison President Bush expressed in his State of the Union when he said, "America is on the verge of technological breakthroughs that … will help us to confront the serious challenge of global climate change."

Recommendation 5:
DoD should conduct an assessment of the impact on U.S. military installations worldwide of rising sea levels, extreme weather events, and other possible climate change impacts over the next 30 to 40 years.

As part of prudent planning, DoD should assess the impact of rising sea levels, extreme weather events, drought, and other climate impacts on its infrastructure so its installations and facilities can be made more resilient.

Numerous military bases, both in the U.S. and overseas, will be affected by rising sea levels and increased storm intensity. Since World War II, the number of overseas bases has diminished, and since the Base Realignment and Closure process began the number of stateside bases has also declined. This makes those that remain more critical for training and readiness, and many of them are susceptible to the effects of climate change. For example, the British Indian Ocean Territory island of Diego Garcia, an atoll in the southern Indian Ocean, is a major logistics hub for U.S. and British forces in the Middle East. It is also only a few feet above sea level at its highest point. The consequences of the losing places like Diego Garcia are not insurmountable, but are significant and would require advance military planning. The Kwajalein is a low-lying atoll, critical for space operations and missile tests. Guam is the U.S. gateway to Asia and could be moderately or severely affected by rising sea levels. Loss of some forward bases would require us to have longer range lift and strike capabilities and possibly increase our military's energy needs.

Military bases on the eastern coast of the U.S. are vulnerable to hurricanes and other extreme weather events. In 1992, Hurricane Andrew virtually destroyed Homestead Air Force Base in Florida. In 2004 Hurricane Ivan knocked out Naval Air Station Pensacola for almost a year. Most U.S. Navy and Coast Guard bases are located on the coast, as are most U.S. Marine Corps locations. The Army and Air Force also operate bases in low-lying or coastal areas. One meter of sea level rise would inundate much of Norfolk, Virginia, the major East Coast hub for the U.S. Navy. As key installations are degraded, so is the readiness of our forces.

APPENDICES

APPENDIX 1:

BIOGRAPHIES, MILITARY ADVISORY BOARD MEMBERS

ADMIRAL FRANK "SKIP" BOWMAN, USN (Ret.)

Former Director, Naval Nuclear Propulsion Program;

Former Deputy Administrator-Naval Reactors, National Nuclear Security Administration

Admiral Skip Bowman was director, Naval Nuclear Propulsion, Naval Sea Systems Command. Prior assignments include deputy administrator for naval reactors in the Naval Nuclear Security Administration, Department of Energy; chief of naval personnel; and director for Political-Military Affairs and deputy director of naval operations on the Joint Staff.

He was commissioned following graduation in 1966 from Duke University. In 1973, he completed a dual master's program in nuclear engineering and naval architecture/marine engineering at the Massachusetts Institute of Technology and was elected to the Society of Sigma Xi. Admiral Bowman has been awarded the honorary degree of Doctor of Humane Letters from Duke University.

In 2005, Admiral Bowman was named president and CEO of the Nuclear Energy Institute. NEI is the policy organization for the commercial nuclear power industry. In 2006, Admiral Bowman was made an Honorary Knight Commander of the Most Excellent Order of the British Empire in recognition of his commitment in support of the Royal Navy submarines program.

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (Ret.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

Prior to his retirement from the Air Force in 1998, General Farrell served as the deputy chief of staff for plans and programs, Headquarters U.S. Air Force, Washington, D.C. He was responsible for planning, programming and manpower activities within the corporate Air Force and for integrating the Air Force's future plans and requirements to support national security objectives and military strategy.

Previous positions include vice commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio, and deputy director, Defense Logistics Agency, Arlington, Virginia. He also served as deputy chief of staff for plans and programs at Headquarters U.S. Air Force in Europe. A command pilot with more than 3,000 flying hours, he flew 196 missions in Southeast Asia and commanded the 401st Tactical Fighter Wing, Torrejon Air Base, Spain. He was also the system program manager for the F-4 and F-15 weapons systems with the Air Force Logistics Command, Hill Air Force Base, Utah.

General Farrell is a graduate of the Air Force Academy with a bachelor's degree in engineering and an MBA from Auburn University. Other education includes the National War College and the Harvard Program for Executives in National Security.

General Farrell became the president and CEO of the National Defense Industrial Association in September 2001.

VICE ADMIRAL PAUL G. GAFFNEY II, USN (Ret.)

Former President, National Defense University; Former Chief of Naval Research and Commander, Navy Meteorology and Oceanography Command

Admiral Gaffney has been the Naval Research Laboratory commander and worked in a number of other science and oceanography administration assignments. He served as the 10th president of the National Defense University, and before that as chief of naval research. He also was the senior uniformed oceanography specialist in the Navy, having served as commander of the Navy Meteorology and Oceanography Command from 1994 to 1997. He was appointed by President George W. Bush to the Ocean Policy Commission and served during its full tenure from 2001 to 2004. He served in Japan, Vietnam, Spain, and Indonesia, and traveled extensively in official capacities.

He has been recognized with a number of military decorations; the Naval War College's J. William Middendorf Prize for Strategic Research, the Outstanding Public Service Award from the Virginia Research and Technology Consortium, and the Potomac Institute's Navigator Award. He has served on several boards of higher education and was a member of the Ocean Studies Board of the National Re-search Council from 2003 to 2006. He has been selected to be a public trustee for the New Jersey Consortium and chaired the Governor's Commission to Protect and Enhance New Jersey's Military Bases.

He graduated from the U.S. Naval Academy in 1968 and has a master's degree in mechanical engineering (ocean) from Catholic University and a master's of business administration from Jacksonville University.

Admiral Gaffney is currently the president of Monmouth University in West Long Branch, New Jersey.

GENERAL PAUL J. KERN, USA (Ret.)

Former Commanding General, U.S. Army Materiel Command

General Kern was commanding general, Army Material Command from 2001 to 2004, and senior adviser for Army Research, Development, and Acquisition from 1997 to 2001.

General Kern had three combat tours. Two were in Vietnam as a platoon leader and troop commander. His third was as commander of the Second Brigade of the 24th Infantry in Desert Shield/Desert Storm. The Second Brigade played a pivotal role in the historic attack on the Jalibah Airfield, which allowed the Twenty-Fourth Infantry Division to secure key objectives deep inside of Iraq. He also served as the assistant division commander of the division after its redeployment to Fort Stewart, Georgia.

General Kern's assignments included senior military assistant to Secretary of Defense William Perry. During that period, he accompanied Secretary Perry to more than 70 countries, meeting numerous heads of state, foreign ministers, and international defense leaders. He participated in U.S. operations in Haiti, Rwanda, Zaire, and the Balkans, and helped promote military relations in Central and Eastern Europe, South America, China, and the Middle East.

General Kern received the Defence and Army Distinguished Service Medals, Silver Star, Defense Superior Service Medal, Legion of Merit, two Bronze Star Medals for valor, three Bronze Star Medals for service in combat, and three Purple Hearts. He has been awarded the Society of Automotive Engineers Teeter Award, the Alumni Society Medal from the University of Michigan, and the German Cross of Honor of the Federal Armed Forces (Gold).

A native of West Orange, New Jersey, General Kern was commissioned as an armor lieutenant following graduation from West Point in 1967. He holds master's degrees in both civil and mechanical engineering from the University of Michigan, and he was a Senior Security Fellow at the John F. Kennedy School of Government at Harvard University.

He is an adviser to Battelle Memorial Institute and holds the Chair of the Class of 1950 for Advanced Technology at the United States Military Academy.

General Kern is a member of the Cohen Group, which provides strategic advice and guidance to corporate clients.

ADMIRAL T. JOSEPH LOPEZ, USN (Ret.)

Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

Admiral Lopez's naval career included tours as commander-in-chief of U.S. Naval Forces Europe and commander-in-chief, Allied Forces, Southern Europe from 1996 to 1998. He commanded all U.S. and Allied Bosnia Peace Keeping Forces in 1996; he served as deputy chief of naval operations for resources, warfare requirements and assessments in 1994 to 1996.; commander of the U.S. Sixth Fleet in 1992 to 1993; and senior military assistant to the secretary of defense in 1990 to 1992.

Admiral Lopez was awarded numerous medals and honors, including two Defence Distinguished Service Medals, two Navy Distinguished Service Medals, three Legion of Merits, the Bronze Star (Combat V), three Navy Commendation Medals (Combat V) and the Combat Action Ribbon. He is one of just two flag officers in the history of the U.S. Navy to achieve four-star rank after direct commission from enlisted service.

He holds a bachelor's degree (cum laude) in international relations and a master's degree in management. He has been awarded an honorary doctorate degree in humanities from West Virginia Institute of Technology and an honorary degree in information technology from Potomac State College of West Virginia University.

Admiral Lopez is president of Information Manufacturing Corporation (IMC), an information technology service integrator with major offices in Manassas, Virginia, and Rocket Center, West Virginia.

ADMIRAL DONALD L. "DON" PILLING, USN (Ret.)

Former Vice Chief of Naval Operations

Admiral Pilling assumed duties as the 30th vice chief of naval operations, the Navy's chief operating officer and second-ranking officer, from November 1997 until his retirement from active service in October 2000.

Ashore, he was assigned to a variety of defense resources and planning billets. In his earlier career, he served four years in program analysis and evaluation in the Office of the Secretary of Defense. As a more senior officer, he served as a Federal Executive Fellow at the Brookings Institution in 1985-86. A member of the National Security Council staff from 1989 until 1992, Admiral Pilling was selected to flag rank in 1989 while serving there. From 1993 to 1995, he was the director for programming on the staff of the Chief of Naval Operations, and later served as the Navy's chief financial officer from 1996 to 1997.

Admiral Pilling also commanded a warship; a destroyer squadron; a cruiser destroyer group; a carrier battle group; the U.S. Sixth Fleet, and NATO's Naval Striking and Support Forces Southern Europe.

Admiral Pilling has a bachelor's degree in engineering from the U.S. Naval Academy and a doctorate in mathematics from the University of Cambridge.

He served as vice president for strategic planning at Battelle Memorial Institute and became president and CEO of LMI, a nonprofit research organization, in 2002.

ADMIRAL JOSEPH W. PRUEHER, USN (Ret.)

Former Commander-in-Chief of the U.S. Pacific Command (PACOM) and Former U.S. Ambassador to China

Admiral Prueher completed thirty-five years in the United States Navy in 1999. His last command was commander-in-chief of the U.S. Pacific Command (CINCPAC); the largest military command in the world, spanning over half the earth's surface and including more than 300,000 people. Admiral Prueher also served as ambassador to China from 1999 to 2001. He served two presidents and was responsible for directing, coordinating, and managing the activities of all United States executive branch activities in China.

From 1989 through 1995, Admiral Prueher served as commandant at the U.S. Naval Academy at Annapolis; commander of Carrier Battle Group ONE based in San Diego; commander of the U.S. Mediterranean Sixth Fleet and of NATO Striking Forces based in Italy; and as vice chief of naval operations in the Pentagon.

Admiral Prueher graduated from Montgomery Bell Academy in Nashville, Tennessee, and then graduated with distinction in 1964 from the U.S. Naval Academy, later receiving a master's degree in international relations from George Washington University. He is also a graduate of the Naval War College in Newport, Rhode Island. In addition to co-authoring the Performance Testing manual used by naval test pilots for many years, he has published numerous articles on leadership, military readiness, and Pacific region security issues. Admiral Prueher has received multiple military awards for combat flying as well as naval and Joint Service. The governments of Singapore, Thailand, Japan, Korea, the Philippines, Indonesia, and Australia have decorated him.

Admiral Prueher is a consulting professor at Stanford University's Institute of International Studies and senior adviser on the Preventive Defense Project. He is on the board of trustees of the Nature Conservancy of Virginia.

GENERAL GORDON R. SULLIVAN, USA (Ret.)

Chairman, Military Advisory Board

Former Chief of Staff, U.S. Army

General Sullivan was the 32nd chief of staff—the senior general officer in the Army and a member of the Joint Chiefs of Staff. As the chief of staff of the Army, he created the vision and led the team that helped transition the Army from its Cold War posture.

His professional military education includes the U.S. Army Armor School Basic and Advanced Courses, the Command and General Staff College, and the Army War College. During his Army career, General Sullivan also served as vice chief of staff in 1990 to 1991; deputy chief of staff for operations and plans in 1989 to 1990; commanding general, First Infantry Division (Mechanized), Fort Riley, Kansas, in 1988 to 1989; deputy commandant, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, in 1987 to 1988; and assistant commandant, U.S. Army Armor School, Fort Knox, Kentucky, from 1983 to 1985. His overseas assignments included four tours in Europe, two in Vietnam and one in Korea. He served as chief of staff to Secretary of Defense Dick Cheney in the administration of President George H.W. Bush.

General Sullivan was commissioned a second lieutenant of armor and awarded a bachelor of arts degree in history from Norwich University in 1959. He holds a master's degree in political science from the University of New Hampshire.

General Sullivan is the president and chief operating officer of the Association of the United States Army, headquartered in Arlington, Virginia. He assumed his current position in 1998 after serving as president of Coleman Federal in Washington, D.C.

VICE ADMIRAL RICHARD H. TRULY, USN (Ret.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

Admiral Truly served as NASA's eighth administrator from 1989 to 1992, and his career in aviation and space programs of the U.S. Navy and NASA spanned 35 years. He retired as a vice admiral after a Navy career of more than thirty years. As a naval aviator, test pilot and astronaut, he logged over 7,500 hours and made over 300 carrier-arrested landings, day and night.

Admiral Truly was the first commander of Naval Space Command from 1983 to 1986 and became the first naval component commander of U.S. Space Command upon its formation in 1984. While still on active duty following the *Challenger* accident, he was called back to NASA as associate administrator for space flight in 1986 and led the accident investigation. He spearheaded the painstaking rebuilding of the space shuttle, including winning approval of President Reagan and the Congress for building of *Endeavor* to replace the lost *Challenger*. In 1989, President Reagan awarded him the Presidential Citizen's Medal.

Truly's astronaut career included work in the Air Force's Manned Orbiting Laboratory program, and NASA's Apollo, Skylab, Apollo-Soyuz and space shuttle programs. He piloted the *747/Enterprise* approach and landing tests in 1977, and lifted off in November 1981 as pilot aboard *Columbia*, the first shuttle to be reflown into space, establishing a world circular orbit altitude record. He commanded *Challenger* in August-September 1983, the first night launch/landing mission of the space shuttle program.

He served as vice president of the Georgia Institute of Technology and director of the Georgia Tech Research Institute (GTRI) from 1992 to 1997. Admiral Truly retired in January 2005 as director of the Department of Energy's National Renewable Energy Laboratory (NREL).

Truly is a member of the National Academy of Engineering. He has previously served on the board of visitors to the U.S. Naval Academy, the Defense Policy Board, the Army Science Board, and the Naval Studies Board. He is a member of the National Research Council Space Studies Board, a trustee of Regis University and the University Corporation for Atmospheric Research, and a member of the advisory committee to the Colorado School of Mines Board of Trustees.

GENERAL CHARLES F. "CHUCK" WALD, USAF (Ret.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM)

From 2001 to 2002 General Wald was deputy chief of staff for air and space operations at the Pentagon, and from December 2002 until his retirement in 2006 General Wald was deputy commander, Headquarters U.S. European Command, Stuttgart, Germany. USEUCOM is responsible for all U.S. forces operating across 91 countries in Europe, Africa, Russia, parts of Asia and the Middle East, and most of the Atlantic Ocean.

General Wald commanded the 31st Fighter Wing at Aviano Air Base, Italy, where on Aug. 30, 1995, he led one of the wing's initial strike packages against the ammunition depot at Pale, Bosnia-Herzegovina, in one of the first NATO combat operations. General Wald commanded the Ninth Air Force and U.S. Central Command Air Forces, Shaw Air Force Base, South Carolina, where he led the development of the Afghanistan air campaign for Operation Enduring Freedom, including the idea of embedding tactical air control parties in ground special operations forces. He has combat time as an O-2A forward air controller in Vietnam and as an F-16 pilot flying over Bosnia. The general has served as a T-37 instructor pilot and F-15 flight commander. Other duties include chief of the U.S. Air Force Combat Terrorism Center, support group commander, operations group commander, and special assistant to the chief of staff for National Defense Review. He was also the director of strategic planning and policy at Headquarters U.S. Air Force, and served on the Joint Staff as the vice director for strategic plans and policy.

General Wald is a command pilot with more than 3,600 flying hours, including more than 430 combat hours over Vietnam, Cambodia, Laos, Iraq, and Bosnia. The general earned his commission through the Air Force ROTC program in 1971.

Currently, General Wald serves as president of Wald and Associates, an international management consulting and strategic planning firm, and is an adjunct lecturer at the Atlantic Council. He is also a member of the Bipartisan Policy Center, National Commission on Energy Policy, and the Securing America's Future Energy Commission.

GENERAL ANTHONY C. "TONY" ZINNI, USMC (Ret.)

Former Commander-in-Chief of U.S. Central Command (CENTCOM)

General Zinni's joint assignments included command of U.S. Central Command (CENTCOM), which is responsible for U.S. military assets and operations in the Middle East, Central Asia and East Africa.

General Zinni's joint assignments also include command of a joint task force and he has also had several joint and combined staff billets at task force and unified command levels. He has made deployments to the Mediterranean, the Caribbean, the Western Pacific, Northern Europe, and Korea. He has held numerous command and staff assignments that include platoon, company, battalion, regimental, Marine Expeditionary Unit, and Marine expeditionary force command. His staff assignments included service in operations, training, special operations, counter-terrorism and manpower billets. He has also been a tactics and operations instructor at several Marine Corps schools and was selected as a fellow on the Chief of Naval Operations Strategic Studies Group.

General Zinni joined the Marine Corps in 1961 and was commissioned an infantry second lieutenant in 1965. General Zinni holds a bachelor's degree in economics from Villanova University, a master's in international relations from Salvae Regina College, a master's in management and supervision from Central Michigan University, and honorary doctorates from William and Mary College and the Maine Maritime Academy.

He has worked with the University of California's Institute on Global Conflict and Cooperation, the U.S. Institute of Peace, and the Henry Dunant Centre for Humanitarian Dialogue in Geneva. He is on the International Council at the Joan B. Kroc Institute for Peace and Justice. He is also a Distinguished Advisor at the Center for Strategic and International Studies, a member of the Council on Foreign Relations. He has also been appointed as a member of the Virginia Commission on Military Bases.

General Zinni has co-authored, with Tom Clancy, a New York Times bestseller on his career entitled *Battle Ready*. His book, *The Battle For Peace: A Frontline Vision Of America's Power And Purpose*, was published in 2006.

APPENDIX 2:
CLIMATE CHANGE SCIENCE—A BRIEF OVERVIEW

There is a vast amount of scientific literature on the subject of climate change, and a complete discussion on the current state of the world climate and its deviation from climatological norms could fill volumes. In this appendix we discuss the consensus of the science community on climate change, effects observed thus far, and projections about what may happen in the future.

We have drawn information from the Intergovernmental Panel on Climate Change (IPCC), peer-reviewed scientific literature, and data, reports, and briefings from various respected sources, including the National Academy of Sciences, National Oceanic and Atmospheric Administration, National Air and Space Administration, and the United Kingdom's Hadley Centre for Climate Change

CURRENT CONSENSUS

The IPCC's latest assessment report affirmed the following:

- While natural forces have influenced the earth's climate (and always will), human-induced changes in levels of atmospheric greenhouse gases are playing an increasingly dominant role.
- After considering the influences of the known causes of climate change—natural- and human-induced—the significant increase in the average global temperatures over the last half century can be attributed to human activities with a certainty of more than 90 percent [7].
- Those temperature increases have already affected various natural systems in many global regions.
- Future changes to the climate are inevitable.

CHANGING GLOBAL TEMPERATURES

INCREASED CARBON MEANS INCREASED TEMPERATURES

Throughout its history, the earth has experienced oscillations between warm and cool periods. These shifts in climate have been attributed to a variety of factors, known as "climate forcings," that include orbital variations, solar fluctuations, landmass distribution, volcanic activity, and the atmosphere's concentration of greenhouse gases, such as carbon dioxide, methane, and water vapor. The changes we see today are occurring at a more rapid rate than is explainable by known natural cycles [15].

Throughout the earth's past, temperature and greenhouse gas concentration have been closely linked through the planet's natural greenhouse effect; i.e. greenhouse gases trap heat in the atmosphere and thereby warm the earth. Throughout Earth's previous four glacial and warming cycles, atmospheric CO_2 concentration, and temperature show a high degree of correlation. Other greenhouse gases, such as methane, also show a similar relationship with temperature.

The recent and rapid rise in atmospheric CO_2 levels is of concern to climate scientists and policymakers. CO_2 concentrations never exceeded 300 parts per million by volume (ppmv) during previous large swings in climate conditions, but the CO_2 concentration now is about 380 ppmv [41], representing a 35 percent increase since the onset of the industrial revolution in the mid-eighteenth century. CO_2 levels are likely at their highest levels in the last 20 million years, and "the current rate of increase is unprecedented during at least the last 20,000 years" [41].

Thus, the current atmosphere is significantly different from its preindustrial state in a way that is compatible with increased heating.

AVERAGE GLOBAL TEMPERATURES HAVE ALREADY BEGUN TO RISE

Average global surface temperature is the most fundamental measure of climate change, and there is no dispute that the earth's average temperature has been increasing over the last century (albeit not uniformly), with an acceleration in warming over the last 50 years. Over the last century, the average surface temperature around the world has increased by 1.3°F ± 0.3°F [7]. Temperatures since the 1950s were "likely the highest [of any 50-year period] in at least the past 1,300 years" [7]. Of the hottest twelve years on record since temperatures began to be measured in the 1850s, eleven have occurred in the last twelve years [7].

The burning of fossil fuels (such as oil, natural gas, and coal) is the main source of the rise in atmospheric CO_2 over the last two and a half centuries; deforestation and other changes in land use are responsible for a portion of the increase as well.

Human activities have also been responsible for a portion of the rise in other heat-trapping greenhouse gases, such as methane, which has risen 148 percent since preindustrial times, and nitrous oxide, which has risen 18 percent during the same period. Currently, half of the annual methane emitted is from activities such as burning fossil fuel and agricultural processes; [41] humans are responsible for about a third of nitrous oxide emissions, mainly from agriculture.

There is no known natural forcing that can account for the severity of the recent warming. For example, while claims are made that variation in the intensity of the sun is responsible, the variation in solar radiation's effect on the climate is estimated to be less than 5 percent as strong as that of human-induced greenhouse gases [7].

MORE THAN TEMPERATURE RISE: OBSERVED IMPACTS ON EARTH'S NATURAL SYSTEMS

A 1.3°F increase in average global surface temperature over the last century may seem like an insignificant change, but in fact it has had a marked impact on many of the earth's natural systems.

PRECIPITATION PATTERNS HAVE CHANGED

A change in the temperature of the atmosphere has a great impact on pre-cipitation patterns. As an air mass warms, it is able to hold more water vapor, so a warmer atmosphere can absorb more surface moisture and produce drier ground conditions. However, this increase in atmospheric content will also lead to more severe heavy rain events, when this higher water-content atmosphere drops its moisture.

Changes in precipitation amounts have been detected over large portions of the world. Annual precipitation has increased 5 to 10 percent over the past century across eastern North America, northern Europe, and northern and central Asia [7, 41]. The Mediterranean region experienced drying [7]. The tropics have witnessed a slightly lower increase, of 2 to 3 percent, and most of sub-Saharan Africa has shown a decrease in precipitation of 30 to 50 percent [42].

The Northern Hemisphere subtropics experienced a decrease in precipitation of approximately 2 percent [41]. Some of the most noticeable drying occurred in the Sahel and portions of southern Asia [7]. No significant change was detected in rainfall patterns across wide areas in the Southern Hemisphere; however, precipitation was noticeably decreased in southern Africa [41].

EXTREME WEATHER EVENTS ARE MORE FREQUENT

Since 1950, cold days and nights and frost days have become less frequent, while hot days and nights and heat waves have become more frequent [7].

Global patterns of both heavy precipitation events and intense droughts have changed over recent decades. The increase in heavy precipitation events is consistent with the general increase in temperatures and the commensurate increase in atmospheric water vapor content. Droughts have become more intense, particularly in the tropics and subtropics, because of higher temperatures, more frequent heat waves, and changes in precipitation patterns [7].

The combination of increasing atmospheric temperatures and increased sea surface temperatures can increase the energy of tropical storms [43]. Preliminary observations since 1970 suggest that this effect has been observed in the North Atlantic and perhaps other regions as well [7].

ICE AND SNOW COVER IS DISAPPEARING

Glacial ice and snow cover are disappearing in many regions around the world. The Arctic region, in particular, is one of the areas being affected most by rising temperatures. As a result of temperatures that have increased at nearly twice the global average rate, Arctic sea ice is thinning and shrinking in extent, glaciers are melting throughout the region, and the snow season has shortened. Alaskan glaciers have retreated at a rapid pace; in fact, the amount of glacial mass lost in Alaska alone represents half of the estimated worldwide total [44]. There will be little to no sea ice in the Arctic's summers toward the end of this century [7]. Glaciers in other regions, such as high-altitude glaciers in tropical areas, are also melting at an increasing rate [7].

Increased melting of the Greenland ice sheet is one of the most worrisome Earth responses observed thus far. Data from NASA's Goddard Space Flight Center show that the seasonal melt area over Greenland has trended upward at 7 percent per year over the last twenty-five years, and the ice shelf surrounding Greenland has thinned by 230 feet over the last five years [15]. Recent satellite data analyzed by NASA have shown that from 2003 through 2005, Greenland annually lost three times more ice through melting than it gained through snowfall [45].

Antarctica's ice cover has also responded to the increasing temperature, but in different ways. West Antarctica has lost ice mass, while the ice sheet in East Antarctica has thickened. The thickening has been explained as being due to increased snow fall (as a result of warming temperatures that lead to more water vapor in the atmosphere) [45] as well as a slowing of glaciers for reasons unrelated to climate [46].

The melting of ice cover is an important positive feedback that reinforces heating, because of ice's contribution to the reflectivity of the earth. As ice melts, it exposes either land or water, depending on its location. Because land and water both reflect less solar radiation than ice, they reinforce rising temperatures, which in turn melts more ice. Once such loops begin, predicting their stopping point is difficult.

OCEANS ARE WARMING

The oceans have an enormous capacity to hold heat: because of their volume and heat capacity they require extremely large inputs of heat to change their temperatures. Nevertheless, the global mean sea surface temperature increased 0.9°F globally in the twentieth century [47], and the IPCC stated that "global ocean heat content has increased significantly since the late 1950s" [41].

SEA LEVELS ARE RISING

Ocean temperature is important to sea level rise because as temperatures increase, water expands, causing sea levels to rise. Because of the thermal inertia of the oceans, once sea level begins to rise because of thermal ex-pansion, it will continue to do so for centuries regardless of any mitigative actions.

Sea levels are also raised by the melting of land-based ice and snow because of the direct transfer of water into the sea. Sea-based ice, however, does not raise sea levels as it melts.

From 1961 through 2003, global mean sea level has risen about three inches, with nearly half of that increase occurring between 1993 and 2003 [7]. Over the entirety of the twentieth century, sea levels have risen nearly seven inches. The IPCC concluded that this rise was caused by thermal expansion of the ocean as well as melting of mountain glaciers and snow cover [7].

OCEAN SALINITY HAS CHANGED

Oceanographers have observed dramatic changes in salinity levels in the oceans. Oceans in the mid- and high latitudes have shown evidence of freshening, while those in tropical regions have increased in salinity [7].

Increases in ocean acidity have also been observed since preindustrial times. Increased atmospheric CO_2 is absorbed in the ocean where it combines with water to form carbonic acid, a mild acid. Most people are familiar with acid rain; this is its ocean equivalent. Forecasts project the increase in acidity over the coming century to be three times as great as the increase over the last 250 years [7]. Higher acidity could have a major impact on ocean life by preventing the formation of shells and skeletons of some very numerous and important zooplankton [48]. Coral reefs are particularly vulnerable.

FUTURE SCENARIOS: A CHOICE FOR HUMANS

To help illustrate the changes in climate that may occur, the IPCC developed a set of more than three dozen scenarios that describe different paths along which the world may evolve over the next century [49]. These paths are divided into six overarching categories distinguished by the assumptions made for factors such as economic growth, interactions among nations, population growth, and technological advances.

The scenarios were used as inputs to drive various climate models. The IPCC's 2007 report documents a range of climate change outcomes for the next century for each of the six categories used. According to the IPCC report, when considering the climate model results for each scenario, the average temperature projected in years 2090 to 2099 is expected to exceed the average temperature observed from 1980 to 1999 by 2.0° to 11.5°F. Sea levels are projected to rise between seven and twenty-three inches. This projection does not include the effect of potential changes in ice flow dynamics of large, land-based glaciers that may further contribute to the rise in sea level. To put this in perspective, recall that over the last century, the temperature increased about 1.3°F, and the sea level increased seven inches.

Because most of the inter-model studies assessed by the IPCC focus on three specific scenario categories, the IPCC's 2007 report necessarily focuses mostly on the same three. The "low" scenario (i.e., the one that results in the lowest temperature increase) describes a future in which population levels come under control, the global economy moves away from a manufacturing focus, and nations work together on improvements in environmental sustainability and developing clean technologies. The "medium" scenario describes a future where the assumptions regarding population and economic growth are similar to those made in the low scenario. Moreover, in the "medium" scenario the IPCC assumes the development of efficient technologies, and the production of energy from a variety of sources other than fossil fuels. The "high" scenario is the same as the "middle" scenario except energy production remains heavily focused on fossil fuel sources.

Each of the IPCC scenarios lead to different projections for temperature change; however, they all project significant global warming, with the most intense warming occurring in the Arctic and the high northern latitudes.

Some of the areas hardest hit by temperature increases will also very likely experience significantly less rainfall by the end of the century. Domestically, the southwestern portion of the United States will very likely experience the worst combination of these factors. Decreasing precipitation and markedly increasing temperatures will also stress northern and southern Africa and the Middle East.

While the earth's natural systems will continue to experience greater stress due to future climate changes, so will some key human systems [24]:

- **Coastal populations:** Increases in flooding and inundation from rising seas and more intense storms will affect coastal populations across the world, particularly those in Bangladesh and low-lying island nations.
- **Agriculture:** Temperature increases of a few degrees and increases in atmospheric CO_2 levels

may help agricultural productivity in mid- and high latitudes but will surely hurt agriculture in the tropics and subtropics, where crops already exist at the top of their temperature range; higher increases in temperature, as well as heat waves, changes in precipitation, and increased pests, will hurt agricultural productivity across much of the globe.

• Water resources: Five billion people are expected to live in water-stressed countries by 2025 even without factoring in climate change. Expected changes in climate will exacerbate water-stress in some areas (including most of Asia, southern Africa, and the Mediterranean), while alleviating it in others (such as the United Kingdom). Areas that depend on tropical mountain glaciers for water (such as Lima, Peru), will face a precarious situation as the glaciers continue to melt and eventually disappear. Developing nations with little capacity to manage water will be among the hardest hit.

• Health: Rising temperatures and heat waves will increase the number of heat-related deaths in summer months. This increase will be partially offset by decreases in cold-related winter deaths. The reach of vector-borne diseases, such as malaria and dengue fever, is expected to spread. Increasing frequency of floods will harm human health by its direct impact on populations as well as by facilitating the spread of disease to affected areas. Vital health infrastructure can be damaged, making minor and treatable injuries become life-threatening.

A WILD CARD: ABRUPT CLIMATE CHANGE

For many years it was believed that climate changes have been gradual—that the earth gradually cycles between glacial periods and warm interglacial periods. We now know this is not always the case [50].

Abrupt climate changes present the most worrisome scenario for human societies because of the inherent difficulties in adapting to sudden changes. Abrupt sea level rise is particularly worrisome. The great ice sheets along the edges of Greenland and the West Antarctic are vulnerable to sudden breakup: as the edges of the sheet thaw and meltwater seeps to the ice-ground boundary, the meltwater will act as a lubricant and facilitate a slippage into the sea. This physical phenomenon is an example of a positive feedback mechanism that, once started, is difficult to reverse [15]. Melting of these ice sheets would be catastrophic. The Greenland Ice Sheet could raise sea levels by twenty-three feet over a millennium [7]; the West Antarctic Ice Sheet would have a more immediate impact, raising sea levels more than three feet per century for five centuries [41]. The probability of a collapse of the West Antarctic Ice Sheet before 2100 is estimated to be between 5 and 10 percent [7].

None of these abrupt climate changes are projected by the climate models driven by the IPCC's 2007 future scenarios. However, if temperature increases were at the high end of the ranges projected by the models, abrupt climate changes such as those discussed above are more likely to occur. Such abrupt climate changes could make future adaptation extremely difficult, even for the most developed countries.

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Senator BOXER. So, Mr. Klesse, I just would like to ask you, do you see any truth in what I have just stated, or are we so many miles apart here?

Mr. KLESSE. Thank you, Chairman. Chairwoman. No. First off, we are not against working on the climate change issue.

Senator BOXER. Good.

Mr. KLESSE. I stated that. The military is talking about the climate change. I was speaking about fuels and the sourcing of fuels. We do import crude oil today, and we also import some products. The domestic refining industry, though, the jobs are here in the United States. The fuels are generated here in the United States from crude oil that comes from all over the world.

Senator BOXER. Right.

Mr. KLESSE. If we want more crude oil, which is a whole different subject, and we are not in that business, so it is very easy for me to speak about it, we should let the industry drill, and we should figure out how to hold them accountable. And as I said, we are not in that business.

Senator BOXER. I understand.

Mr. KLESSE. But I was talking about fuels. And if you—the actions that are being taken will adversely affect the domestic refining industry. It will cause jobs to leave. Those fuels will have to be sourced elsewhere.

Senator BOXER. Thank you.

Mr. KLESSE. No, green jobs, just, if I can, we are supportive of green jobs. We are not against green jobs.

Senator BOXER. Good.

Mr. KLESSE. I told you we have a wind farm. So, we are not again those.

Senator BOXER. Good. Well, I am glad we have some areas where we can——

Mr. KLESSE. We have a lot of areas of agreement.

Senator BOXER. Good. I am very glad. I want you to know, just in the bill, because it may, and I want to share this with you afterwards because my time is expiring here, I want you to see what we have tried to do to lessen the blow on the refineries, because we do have a lot of allowances going in that direction. But I will show you after this is over, if you——

Senator KLESSE. If I could just comment on——

Senator BOXER. I must——

Mr. KLESSE. In your State of California, at 2 percent allocation, Valero will have to buy, just for California, $850 billion of carbon credits in one form of another, and that is adjusted for the 2 percent.

Senator BOXER. Well, let me again reiterate. What we are doing in our bill is we are trying to ease the burden on the smaller refiners, and we have a study here we will put in the record at the way we are easing the burden on oil. So, we will talk to you about it. We will take a look at it.

And because of the extended answer, I must ask one other question to Mr. Brehm. In your testimony, you discussed the potential for growth of the U.S. solar industry. Can you describe the types of jobs that the cap on carbon in this bill and the additional investment in renewable energy will create? The types of jobs.

Mr. BREHM. As you know from my testimony, we are particularly supportive, and for our company in particular, of U.S. manufacturing jobs. We think those are actually the highest valued, most important jobs because that is where the U.S. has fallen behind in recent years. So, primarily manufacturing. But also, obviously, installer jobs, development jobs, project jobs, the operating jobs of solar facilities so really quite a plethora of across the spectrum jobs and real job generators.

Senator BOXER. Thank you.

Senator Inhofe.

Senator INHOFE. Thank you, Madam Chairman.

Mr. Klesse, you just stated, the very last thing you stated, in the State of California you would be forced, under these provisions, to buy $850 billion what of allowances?

Mr. KLESSE. Assuming that carbon sells for $20 a ton——

Senator INHOFE. OK.

Mr. KLESSE. We would be obligated to buy $850 billion a year——

Senator INHOFE. Just in California?

Mr. KLESSE. Just in California.

Senator INHOFE. Who is going to ultimately pay that?

Mr. KLESSE. Obviously, the refining business is a very low margin business. I know many people do not believe that. But it is. Valero, for instance, in 2006 made as much money as it had made in 25 years before that in the golden age of refining. So we will pass that cost through.

Senator INHOFE. Exactly. So the people of California are going to be paying the $850 billion that you have to pay.

Mr. KLESSE. And they will see the price of fuels go up dramatically.

Senator INHOFE. Yes. OK.

Mr. Klesse, you did not, you alluded to, but did not have time in your opening statement, to talk about all of these organizations in terms of jobs. This is a job panel. We are going to have the National Security Panel in a few minutes. But this is—the CVO has testified to Congress that this, cap and trade, this type of arrangement, would cost a lot of jobs. EPA, CBO, EIA, CRA, the Heritage Foundation, all concluded that the bill would cause job loss.

For example, EIA predicts cap and trade would cost some 2.3 million jobs or 800,000 manufacturing jobs by 2030. Do you agree with that figure?

Mr. KLESSE. I agree that there will be a significant loss of jobs.

Senator INHOFE. Mr. Vassey.

Mr. KLESSE. And I would also add that our people in Paulsboro, New Jersey, where we have a refinery, the building trade union came out yesterday and said very clearly they have no expectation of making solar panels in New Jersey.

Senator INHOFE. OK. Mr. Vassey, you commented on the United States relative to Japan and Western Europe. I did not quite get that in terms of emissions.

Mr. VASSEY. What our basic suggestion is is that you may be looking at the metrics a little wrong from the point of view of how industry is measured in this. If you look at overall carbon emissions of the industrial sector as a percentage of each country's overall emissions, the United States has the lowest at 11.5. Our major trading partners, which just also happen to be those countries trying to push us in this direction, are substantially higher——

Senator INHOFE. Where is China on that?

Mr. VASSEY. China is at 28 percent to our 11.5 percent.

Senator INHOFE. All right. Now, if we all agree, and I think everyone does, in terms of the 2.3 million jobs, then if some of those jobs are going over, obviously if we cannot produce the energy here, those jobs are going to have to find some place where there is energy. Logically, it could be China. It is my understanding that China is cranking out currently some two coal-fired generating plants a week.

Now, if that is the case, would it not be reasonable to assume that if those jobs go from here, where it is 11.5, to China's where it is 28, we could end up with a net increase in emissions by having cap and trade only applying to the country of the United States?

Mr. VASSEY. That is the principle of leakage, which we are trying to point out is that it is pretty obvious that the energy intensive industries that are global will have options to produce in countries where they are wanted.

Senator INHOFE. All right. And Mr. Klesse, you talked about the petrochemical jobs. Do you have any—you may want to do this for the record—any specific details in terms of the jobs that we have already lost? We have information from the NAM and others, but do you have any concerning your specific situation?

Mr. KLESSE. Well, I can comment on Valero. We have reduced personnel in Delaware City. This reflects not only the current economics in the economy, but clearly with this legislation, we will have to reduce and shut down other units. We also have an effort to reduce our costs in Paulsboro, New Jersey, and across our system.

We have shut down units in Aruba, which is outside of the United States but does supply the United States with feed stocks. We have idled that refinery. And one of our competitors has idled a refinery in New Jersey.

Senator INHOFE. All right. Well, let us get for the record specific numbers of people in jobs so we can plug that into the information, the testimony that we have from all of these groups that are already mentioned.

Let me make just one—my time has expired—just make one comment about what I think is going to happen.

When we had the bill, the Markey bill, the Markey-Waxman bill, it passed the House by 219, a bare majority. Some of us are old enough to remember, back in 1993 and 1994 the BTU tax, which was a similar thing in terms of energy costs that we passed on to the American people as we have been talking about. That also passed the House by 219 votes, a bare majority, the same majority. And of course, it did not get anywhere in the Senate.

So I certainly hope that you folks can get into as much detail as you can in terms of the numbers of jobs, manufacturing jobs, Valero jobs, where you think they would go, how that would affect our economy, and do that for the record.

Thank you very much.

Senator BOXER. Thank you, Senator Inhofe.

Mr. KLESSE. Madam Chair, I need to correct. My people tell me I said billions, and it is $850 million a year.

Senator BOXER. That is a big difference.

Mr. KLESSE. It is only a few zeros.

[Laughter.]

Senator BOXER. Well, the reason that is important——

Mr. KLESSE. It is $850 million a year——

Senator BOXER. Yes. And we think you are going to be able to cover that. And we are going to put in the record the Stanford study that shows that the profits will be preserved for these companies. But we will, this is a Stanford research study because of the allowance we are giving out, it is entered.

But I am so happy you corrected the record because my heart stopped myself when you said billions because we have, we believe, covered the problem.

Senator Cardin.

[The referenced information follows:]

Policy Analysis Memo

Profit Impacts of Allowance Allocation under the American Clean Energy and Security (ACES) Act

Michael Dworsky, Marc A. C. Hafstead, and Lawrence H. Goulder, Stanford University

16 September 2009

Introduction

Last June the U.S. House of Representatives approved the American Clean Energy and Security (ACES) Act, a climate bill sponsored by representatives Henry Waxman (D-CA) and Ed Markey (D-MA). The Senate is now drafting its own climate bill. If the Senate approves its own proposal, an integrated House-Senate bill will then be voted on by the full Congress.

A major element of the ACES Act is a federal cap-and-trade system. Under the Act, total emissions of greenhouse gases (GHGs) from major sources face a declining cap. GHG emissions from covered sources would need to decline by 17 percent relative to 2005 levels by 2020 and by 83 percent relative to 2005 by 2050.

The Act would achieve the desired reductions by circulating a limited supply of emissions allowances to various covered industries. The Act's impact on industry profits depends critically on how the value of these allowances is allocated to the covered industries.

This Policy Analysis Memo provides results from simulations with a general equilibrium model relating to allowance allocation under the ACES Act. This memo compares the allowance value allocation under the ACES Act with the allocation that would just maintain the profits of major industrial sectors at their business-as-usual levels.[1] The model shows that the Act provides most industries with more allowance value than would be necessary to maintain profits.

[1] This memo complements our recent SIEPR Policy Brief (Goulder, Hafstead, and Dworsky, 2009a), which examined the profit implications of a range of potential allocation designs. The policy brief did not consider the ACES Act's allocation in any detail. The present memo focuses exclusively and sharply on the Act's allocation.

Allowance Allocation under the ACES Act

The allocation of allowance value follows two distinct regimes under the ACES Act.[2] Prior to 2025, almost all allowance value will be dedicated to reductions in retail energy bills for households and businesses, to direct aid to economically vulnerable industries and groups of households, and for various energy and environmental policy purposes. These goals will be served through both the awarding of free allowances and the use of revenues from auctioned allowances. Most of these provisions phase out between 2026 and 2030, after which time most permits will be auctioned to finance per-capita tax rebates ("Climate Change Consumer Refunds") to households.

Under the ACES Act, in each year to 2025 about 83 percent of the emissions allowances will be freely allocated to various entities, with the remaining 17 percent auctioned. After 2025, about 30 percent will be freely allocated and 70 percent auctioned. The split between free allocation and auctioning of allowances does not by itself affect the distributional impacts of the ACES Act. What is critical is how the *allowance value* is distributed, no matter whether this value is conferred via free emissions allowances (which subsequently can be used or sold) or via transfers of the government's auction revenue to various parties.

Accordingly, we summarize here the Act's allocation provisions by defining five different ways in which the Act distributes allowance value:

- *Direct Allocation to Firms via Free Allowances:* In several industries, firms will receive allowance value directly in the form of free allowances. In the year 2020, for example, up to 18.7 percent of allowances will be directly transferred to petroleum refineries, trade-vulnerable industries, and merchant coal generators.[3]

- *Indirect Allocation to Firms and Households via Local Distribution Companies:* A large share of allowances will be freely allocated to local distribution companies (electric and natural gas utilities). In 2020, for example, this share is 40 percent.[4] The law instructs these utilities to use this allowance value to finance reductions in the energy bills of their industrial, commercial, and residential retail customers. The reductions that accrue to each class of ratepayers is to be proportional to the energy consumption of that class.

- *Direct Transfers to Households:* In every year of the cap-and-trade program, 15 percent of allowances are auctioned to finance lump-sum rebates to low-income households.

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[2] Allowance allocation is addressed in Title VII, Part H of the ACES Act.

[3] Allocations to Trade-Vulnerable Industries and Merchant Coal Generators under the Act are based on each firm's annual sales. In our simulations, we abstract from the output-based nature of these allocations and assume that the maximum allowable quantity of allowances is distributed to each industry group in every year. See the web appendix to this policy analysis memo for details.

[4] The total allocation to electric and natural gas local distribution companies is actually 44 percent in each year during the interval 2016-2025. However, allocations to merchant coal generators are deducted from the pool of allowances allocated to electric utilities, resulting in the 40 percent figure presented here.

Additional allowances – 1.5 percent in the year 2020 – are freely allocated to state governments to fund assistance to non-industrial users of home heating oil. The state governments would subsequently sell these allowances and devote the proceeds to households.

- *Policy Initiatives:* Under the ACES Act, most of the allowance value not dedicated to one of the above three general categories is used to fund over a dozen policy initiatives either by allocating allowances to governments and private actors or through dedicated use of auction revenues. This represents a significant share of the total allowance value – 24 percent in 2020. Among various social, energy, and environmental goals, the largest programs in this category aim to fund energy research, prevent deforestation, and encourage carbon capture and sequestration projects.

- *Deficit Reduction:* In years 2025 and earlier, allowances not elsewhere allocated will be auctioned to finance deficit reduction. The provisions described above absorb most of the allowance value; hence this provision is likely to account for a very small share of total allowances in the cap-and-trade system. Under our assumption that output-based allocations to industry reach the statutory maximum, less than one percent of allowances are available for deficit reduction in 2020.

Table 1 indicates the shares of allowance value falling in each of these five general categories. The first two categories are especially important in our analysis, since they represent sources of the allowance value that firms receive for free. Firms receive this value either directly from the government in the form of allowances, or indirectly through reductions in utility energy bills.

Simulating the ACES Act

We apply a multi-period numerical general equilibrium model of the U.S. economy to assess the profit impacts of the ACES Act's allocations. The model divides U.S. production into 25 industry categories, giving close attention to energy supply and use. The model offers a unique treatment of capital dynamics, enabling it to assess the extent to which firms' assets would be stranded by cap and trade and the associated implications for profits. The model's structure is described in Goulder and Hafstead (2009); its data are documented in Hafstead, Mahoney, and Goulder (2008).

We perform two main types of policy simulations. In one, we allocate allowance value to firms and households according to the specifications of the ACES Act. In the other, we allocate just enough free allowance value to various industries to preserve the profits in those industries. In both simulations, the time-profile of total allowances circulated matches that of the ACES Act.

The provisions of the Act largely focus on quantities of allowances devoted to various purposes. The allowance value associated with these quantities will depend on allowance prices. A critical determinant of these prices is the availability of offsets (see Goulder, Hafstead, and Dworsky, 2009b), and this availability is highly uncertain. Accordingly, we introduce a range of assumptions about the availability of offsets.[5]

Simulation Results

Table 2 shows the results from our simulations under central case assumptions. In the first numbered column we indicate the total allowance value offered free to each of the major industry categories, as well as (in parentheses) the free allowance value offered through direct provision of allowances. The second numbered column shows the percentage changes in the present value of profit over the interval 2009-2030 that result from this freely offered allowance value. The third numbered column indicates the free allowance value that would be needed by each industry category to preserve profit over the 2009-2030 interval.

According to our central case simulations, U.S. industry overall receives about 1.8 times the value of allowances needed to maintain profits. The petroleum refining industry, in particular, receives about two and a half times the value of allowances it would need for profit-preservation. The industries categorized as trade-vulnerable receive about three times as many allowances as profit-maintenance would require. In contrast, coal-fired electricity generators receive about three quarters of the value of allowances needed for profit-preservation. The direct compensation provided in the ACES Act reduces this industry's present-value loss of profits over the interval 2009-2030 to 4.3 percent from a 15.4 percent loss in a scenario where no allowances are given out free.[6]

[5] To estimate an offset supply curve, we begin with the latest EPA estimates on potential domestic and foreign offset supplies. The Congressional Budget Office (CBO) recently reported that the EPA foreign offset estimates do not reflect the true cost due to transaction and verification costs. We scale the foreign offset supply curve to match CBO foreign offset estimates, which are reported in http://www.cbo.gov/ftpdocs/104xx/doc10497/08-03-Offsets.pdf.

[6] Our model may lead us to overestimate of the adverse impact of the ACES Act on coal generators for several reasons:

(i) We model the output-based allocations to merchant coal generators as lump-sum allowance transfers. In fact, output-based allowance allocation effectively provides a subsidy for increased output, which mitigates the impact of emissions caps on firms' profits.

(ii) We have assumed that coal-fired generators receive none of the allowance value that is provided to other industries indirectly by way of local distribution companies. These companies may in practice set rates so that some of this compensation ultimately benefits merchant coal generators or vertically integrated utilities with coal generating assets. Reductions in consumer energy bills – even if confined to the fixed component of those bills, as the law intends – are likely to increase sales, reducing the profit losses to utilities and generators relative to our simulation results. In testimony before the Senate Finance Committee, Burtraw (2009) estimates that this effect would increase generator profits by $2.5 billion per year over 2015-2020 in regions of the country with competitive wholesale markets. Our model does not account for this market response, which is of a similar magnitude to yearly direct compensation to coal generators over this period.

(iii) We do not allow for carbon capture and sequestration (CCS) technology in our simulations. CCS would make the use of coal more economically viable, and the installation of CCS at electric generators would trigger additional allowance allocation to these facilities under Subtitle B of Title I of the ACES Act.

Our central estimate is that, in total, U.S. industry receives $134 billion more in free allowance value over the period 2012-2030 than is needed to preserve profits over that period. This amounts to about $7 billion per year in 2009 present value, or $60 per household per year.[7]

Table 3 compares the ACES Act and profit-preserving allowance value allocation under differing assumptions for the cost of offset supply.[8] In the low-cost offset scenario, offsets play a larger role, reducing the need for emissions reductions from covered domestic sources. This reduces the demand for emissions allowances and leads to lower allowance prices. This implies, in turn, that the allowance *values* associated with the given allocations of emissions allowances under the ACES Act are lower than in the central case. Although the Act still provides more free allowance value than is needed to preserve profits, the difference between what the Act provides and what is needed for profit-preservation is smaller than in the central case. This difference is $90.2 ($210.5-$120.3) billion, as compared with $134.0 ($294.6-$160.6) billion in the central case.

In the high-cost offset case, the effects work in the opposite direction. This scenario implies higher allowance prices and magnifies the differences between the value of allowances provided under the ACES Act and the value needed for profit-preservation. Here the difference is $168.4 ($357.6-$189.2) billion.

Conclusions

The results from our numerical general equilibrium model indicate that by providing U.S. industries with a relatively small fraction of the allowance values created by the ACES Act, profit losses associated with the introduction of a cap-and-trade program can be avoided. Thus, sustaining profits is consistent with devoting to other social purposes a substantial share of the allowance value created by the ACES cap-and-trade program.

We find that the ACES Act provides industry with 75-89 percent more allowance value than is needed to preserve industry profits. The range reflects different assumptions about the costs of supplying offsets. A large fraction of the allowance value received by firms arrives indirectly – after being transformed into reductions in electricity bills. The Act devotes a large share of the allowances to local distribution companies, which would be obligated to sell these allowances and use the proceeds to finance reductions in ratepayer bills, including industrial ratepayers. As a result of the direct and indirect allocation of allowance value, most energy-intensive industries are likely to enjoy increased profits under the ACES Act.

[7] The total number of U.S. households for this calculation is the Census Bureau's estimate for 2008, available at: http://www.census.gov/population/www/socdemo/hh-fam/cps2008.html.

[8] In the low-cost offset case, we assume that the cost at each level of quantity along the supply curve is 50 percent of the cost in the central case. In the high-cost case, we assume the cost is 150 percent of the central case cost.

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Table 1: Allocation of Allowance Value in the ACES Act

-- percentages of total value --

	2020	2012-2030 Average
Free Allocation to Industry		
Direct Allocation via Free Allowances	18.7	15.9
Indirect Allocation via Local Distribution Companies	29.1	25.0
Free Allocation to Households		
Indirect Allocation via Local Distribution Companies	10.9	15.8
Direct Transfers	17.0	15.0
Funding of Policy Initiatives	23.5	26.6
Deficit Reduction	0.8	1.8

Table 2: ACES Act Allocation vs. Profit-Preserving Allocation
Outcomes over the Interval 2009-2030

	(1) ACES ACT: Allowance Value Offered[1,2]	(2) ACES ACT: Percentage Change in Profit[3]	(3) Profit-Preserving Allowance Value[1]	(4) Ratio: (1)/(3)
Coal-Fired Electricity Generation	22.6 (22.6)	-4.3	31.1	0.73
Trade-Vulnerable Industries	143.1 (84.1)	2.1	44.4	3.22
Petroleum Refining	11.3 (10.2)	2.7	4.5	2.50
Other Industries	117.6 (0.0)	0.4	80.6	1.46
Industry Total	**294.6 (117.0)**	**0.5**	**160.6**	**1.83**
Industry Total as Percent of Economy's Allowance Value	40.5 (15.5)		21.3	

Total emissions associated with freely provided allowance value, 2009-2030, in billions of CO_2-equivalent tons:
ACES Act: 56.2
Profit-Preserving Allocation: 17.0

[1] Present value over the period 2009-2030, in billions of 2005 dollars.
[2] The numbers in parentheses are direct free allowances to industry
[3] Percentage change in the present value of profit over the interval 2009-2030

Table 3: Allowance Allocation, 2009-2030, Under Alternative Assumptions for Offset Supply[1]

	Low-Cost Offsets			Central Case			High-Cost Offsets		
	ACES ACT			ACES ACT			ACES ACT		
	Allowance Value Offered	Percentage Change in Profit	Profit-Preserving Allowance Value	Allowance Value Offered	Percentage Change in Profit	Profit-Preserving Allowance Value	Allowance Value Offered	Percentage Change in Profit	Profit-Preserving Allowance Value
Coal-Fired Electricity Generation	16.2	-3.8	23.6	22.6	-4.3	31.1	27.5	-4.5	36.1
Trade-Vulnerable Industries	102.3	1.5	31.5	143.1	2.1	44.4	173.8	2.5	54.3
Petroleum Refining	8.1	1.9	3.2	11.3	2.7	4.5	13.7	3.3	5.5
Other Industries	84.0	0.3	61.9	117.6	0.4	80.6	142.7	0.5	93.2
Industry Total	**210.5**	**0.3**	**120.3**	**294.6**	**0.5**	**160.6**	**357.6**	**0.6**	**189.2**
Industry Total as Percent of Economy's Allowance Value	40.5		22.6	40.5		21.3	40.5		20.9

[1] Values in billions of 2005 dollars

Senator CARDIN. Thank you, Madam Chair. And let me thank all of the witnesses for their testimony.

Let me just urge people to take a look at this entire bill. There are significant amounts of allocations that go to help the consumers and to help industries in transition, which is not reflected in the numbers that we are given. So, I think you need to take a look at what this bill does in its entirety.

And let me talk for a moment about leakage. I heard Senator Voinovich, in his opening statement, talk about the concern about the provision in the House bill which, by the way, is not in the jurisdiction of this committee, so it will be taken up, Senator Carper, in the Finance Committee.

We are concerned about leakage. I think that is an issue we need to work together on. I have urged our negotiators in Copenhagen to deal with enforcement. And I would hope that we would get the support of industry here working with our colleagues around the world to say look, we do need an enforcement provision in the Copenhagen agreements.

We need to set reasonable targets in Copenhagen, we need to have a mechanism to achieve those targets, we need to deal with the financing issues of third world nations, and we need to deal with enforcement.

And we would be far better off if Copenhagen deals with enforcement so that there is an international regime that says that if a country does not do its obligations internationally, such as China or India or any other country, when their products enter the international marketplace that there will be an assessment on that——

[Audio gap.]

We just work together and get that into the Copenhagen agreement. I have not heard very much from industry helping us in putting the focus where it should be in the negotiations that are taking place internationally. And I agree with Senator Voinovich that it would be far better than to try to do deal with this through the WTO and individual countries acting.

So, there are answers to these questions. So, let us work in a constructive way.

Mayor Nutter, I agree completely with your point that where we are looking at the source, where most of the new jobs are going to come in America, are going to come from the new technologies, the technologies that were developed here. This is going to create jobs in our communities.

I have already given examples in my own State of Maryland with the new technologies for automobiles and trucks in White Marsh. I could have used the algae ethanol technology that is being advanced by a relatively small company in downtown Baltimore that is developing this technology that we hope will be able to give us alternative fuels that will not have a disruption on our food chain, which is important, I think, for our economy.

And Mr. Brehm, on solar technology, Maryland is a leader on solar technology. The number you gave, I think you said a 40 percent increase in the first 6 months from last year. That is an incredible growth rate, and I know it is still a relatively small part of the overall mix. But if we can duplicate that type of growth in solar production, that could have a dramatic impact on meeting our needs and creating jobs here locally.

What do we need to do in order to duplicate that and make sure that continues?

Mr. BREHM. Well, clearly the policies advocated by, that would be put in place by this bill, would set the base for the entire renewable energy industry. Because once you get certainty on price on carbon, then people start to make the long-term commitments, the long-term planning.

And then, as some of my colleagues have also commented, incentives it would put in play, that can be put in play to encourage U.S. manufacturing of these technologies, would be hugely beneficial. And I happen to be familiar with, of course, Senator Brown's impact data. But I believe there are some other opportunities out there as well.

The combination basically, this bill here creates a demand. Some other acts that Congress could take on would then create the supply.

Senator CARDIN. Let me, I think that is a critical point. Predictability is so important for investment. Industry knows how to adjust if they know what to expect, and investors will deal with that. I agree with Senator Alexander on the point of nuclear investors. One of the reasons we have been unable to get investors in nuclear energy is because of the uncertainty. We have got to change that.

This bill, I think, in a way does change it. Not in a way. It does change it, because it gives a predictable return for energy sources that have a friendlier carbon footprint. That is going to be good for investors in nuclear energy as it will be in solar energy.

That is what, I think, is the most exciting thing about this bill, Madam Chair, is that we unleash the American economy with predictability so investors can invest and the creative ingenuity can solve this problem and create jobs and keep jobs here in America.

Thank you.

Senator BOXER. Thank you very much.

Senator Alexander.

Senator ALEXANDER. Thank you, Madam Chairman.

I want to go back to Mr. Klesse for just a minute. You mentioned a figure which I think is accurate that refiners in America would have to buy about $63 billion of allowances a year. Am I accurate about that?

Mr. KLESSE. That is assuming $20——

Senator ALEXANDER. The $20. But it could be more than that over time?

Mr. KLESSE. It could be.

Senator ALEXANDER. But let us say, conservatively, that it is $20. Basically, what you are in the business of is taking oil that comes from all around the world, but mostly in the United States, is that right, and turning it in, and refining it in a way that we can drive it in our cars and trucks?

Mr. KLESSE. We take oil from all over the world and refine it. But more oil is imported today than is produced domestically.

Senator ALEXANDER. So, in the scheme of things, the way this bill works, you are responsible for the oil, the fuel that all of us use. If I drive to work in a car, I do not pay anything under this cap and trade bill. You pay it for me, in effect, with the allowances that you would buy every year. Is that right?

Mr. KLESSE. I would pay for the allowances. We would get the allowance, but everything above that we have to assume the cost.

Senator ALEXANDER. Yes, but what you were saying in answer to one of the questions was that $63 billion a year basically would be passed on to the gasoline taxes and fuel taxes we pay. Correct?

Mr. KLESSE. It has to be. This business is very efficient. Our total——

Senator ALEXANDER. Well, let me just ask, have you computed how much of an increase in gas, in fuel prices, that would be?

Mr. KLESSE. There are numerous studies out. We have used in the middle, the 77 cents which in 2019 is the half way. It assumes no international offsets. If you take that number, and today we have $2.50 gasoline, so it would be a third. It is a 30 percent increase.

Senator ALEXANDER. A 30 percent increase. So that is——

Mr. KLESSE. That is from this regulation——

Senator ALEXANDER. From $2.50 to $3.30 or $3.40?

Mr. KLESSE. That would be correct in 2019.

Senator ALEXANDER. Now, we have had testimony from, among others, Dr. David Greene of Oakridge Laboratory, which basically says that an economy-wide cap and trade is a poor way to reduce carbon because it has the effect of raising the price, as you just said, 80 cents, but it is constructive but insufficient impact on vehicle travel and fuel consumption. In other words, that while we bear a lot of pain from the effect of an economy-wide cap and trade on our fuel prices, we might not change our behavior. Do you know anything about, is that true?

Mr. KLESSE. Yes. I understand the questions would be clearly does the higher price, in that range, actually change consumer habits.

Senator ALEXANDER. And your experience is?

Mr. KLESSE. Our experience would be in Europe and in Canada that it may not.

Senator ALEXANDER. That it may not. So, we might have the situation where fuel, being 30 percent of all of the carbon we produce in the United States, we raise the price but do not reduce the carbon. So basically, all we have done with this bill is raise the price of gasoline and fuel.

Mr. KLESSE. That is correct. It is a tax, but it also places this industry at a competitive disadvantage internationally. This is a very global business.

Senator ALEXANDER. Let me ask Ms. Gordon, and to other witnesses, many of you have mentioned clean energy or green energy. Do you mean by that any form of energy that is carbon-free? Do you have a definition for it?

Ms. GORDON. I think that low carbon technologies is usually what we say.

Senator ALEXANDER. Low carbon or no carbon?

Ms. GORDON. Yes.

Senator ALEXANDER. So, would you agree that if we have subsidies and incentives or focus that we ought to look at the whole wide range of low carbon or no carbon——

Ms. GORDON. Sure. I think we should look at a range. We should look at a range that includes cost competitive technologies and measure those the way we measure technology in general.

Senator ALEXANDER. Does anyone on the panel disagree with that? As we generally speak of clean or green technologies, would you agree that we ought to be equally interested in all forms of say, electricity production that would produce no carbon or low carbon electricity. Anyone want to comment on that?

Mr. BREHM. I am speaking for myself and my company. I actually do not know the Solar Energy Industries Association position on nuclear, but we are located actually in eastern Washington, where Hanford is, Hanford Nuclear Site is, Pacific Northwest National Lab, and we are actually very pro-nuclear. We believe that nuclear and solar, in particular, are very complementary.

Senator ALEXANDER. That winds up, my time is about up, but I would like to mention is, according to the Department of Energy, the direct jobs produced by 100 new nuclear reactors would be 250,000. That would be three times as much as building 180,000 wind turbines. Seventy percent of our carbon-free electricity is nuclear, and as I listened to the whole range of panelists, no one mentioned nuclear power, which we invented, which produces 70 percent of our carbon-free electricity, which the rest of the world is using, and we have not started a new nuclear plant in 30 years.

So my plea is, and Senator Cardin mentioned that, he has been a consistent supporter of nuclear power, so if have got a form of energy that will solve our problem, and I will conclude, Madam Chairman, with this comment. My view is that if we built 100 nuclear plants, if we electrify half the cars and trucks, and if we had mini-Manhattan Projects in energy R&D, we could reach the Kyoto goals in 2030.

We have got 40 Republican Senators who support what I just said and many Democrats. I do not know why we do not do it.

Mr. BREHM. May I respond? As far as I am concerned you may. Is this appropriate, Madam Chair?

Senator BOXER. Well, just if you could make it brief because we are over the time. Go ahead.

Mr. BREHM. Again, as I pointed out, we are certainly very pronuclear. But to answer your point earlier, where you talked about France, France also views nuclear and solar as being very complementary. In spite of the fact that France gets 70 percent of their power from nuclear energy, they just implemented one of the strongest pro-solar feed in tariffs in the world. So, they are very complementary technologies.

Senator ALEXANDER. I agree.

Senator BOXER. OK.

Senator Specter.

Senator SPECTER. Thank you, Madam Chairwoman.

Mayor Nutter, it is quite a compliment to the city of Philadelphia that you have been selected to present the testimony for the United States Conference of Mayors. The testimony that you have given is a win-win situation here on green jobs and energy saving.

Mr. NUTTER. Yes.

Senator SPECTER. I note that you have allocated more than $33 million to retrofitting and job training for young people, $14.1 from the formula allocation from the stimulus package and $19 million, $11 million from the Community Development Block Grants. But the city of Philadelphia has put up $8 million on its own, and it provides some 800 trainees with as little as 2 weeks' training on weatherizing and retrofitting.

What kind of an impact do you think that will make on other considerations like crime control in the city of Philadelphia? So that, by putting these people to work, it obviously is a real problem, so you attack the issue in a number of directions, jobs, energy efficiency and crime control.

Mr. NUTTER. Senator Specter, it goes without saying that for the city of Philadelphia specifically, which presently, unfortunately, has an unemployment rate of 10.7 percent, and many economists, local economists, anticipate that will grow, putting people to work has to be our No. 1 priority.

And I would only suggest here that the best anti-crime program is a job, that when people are working, they are much less likely to be involved in negative or illegal activities. That is why we have focused so much of our dollars in the green economy area.

Just this past Monday, I was at a press conference with Maxwell Education Group. They received a $150,000 grant from Workforce Investment, economic recovery dollars. Twenty-four men graduated from their training program. That particular program is 8 weeks. Monday was their last day of training. Every one of them will walk into a job this week. Five of those 24 individuals are ex-offenders, six of them are military veterans most having just recently served in our international war efforts.

These programs work, and they put people to work. All 24 of those men who graduated on Monday are dislocated workers. None of them were currently employed. All of them will be employed by the end of this week.

Senator SPECTER. The important factor, Mayor Nutter, is that the jobs you are giving them will have application in the private sector as well.

Mr. NUTTER. Well, Senator, all 24 of them will be working in private sector jobs. None of them will be working for me or for the city of Philadelphia. The industry is demanding so many workers that there is capacity out there for these individuals. They will all be working in the private sector.

These are not make work jobs. These are not what anyone might think of public service jobs. These are private sector jobs paying a good wage. These individuals will be able to sustain themselves.

And the opportunity for entrepreneurship in this particular industry, I believe, is limitless. People will go from training to entry level jobs and eventually many of those individuals will start companies of their own. And for us, of course, everyone working, paying taxes is what will help turn America's cities around.

Senator SPECTER. I turn now to Mr. David Foster, another Pennsylvanian, a representative of the BlueGreen Alliance launched by the United Steelworkers and also by the Sierra Club in 2006.

I note at the outset that the United Steelworkers, which is very much concerned about jobs and very much concerned about foreign imports and what China and India are doing, has endorsed the House bill.

I was particularly interested in the part of your testimony where you specified that the studies which you have conducted on renewable electricity standards show that there is the potential for creating some 850,000 manufacturing jobs, and you specified quite a number of States. And when it turns to Pennsylvania, 42,000 new jobs will be created.

There have been a lot of comments on the committee about job loss and about impact on the traditional American industries. And there is no industry more zealous of its standing than the Steelworkers. Leo Girard, the president, scoffs at the idea of protectionism and says I want to talk about law enforcement. The Chinese are violating our trade laws under WTO.

My question to you is, explain the confidence level of the United Steelworkers in supporting this kind of legislation when we have heard so many objections raised by some members of this committee on the jobs issue.

Mr. FOSTER. Thank you very much, Madam Chairman.

Senator Specter, I think you have pointed at a very critical issue, and it underscores the fact that, while there is a problem with carbon leakage, as we think about climate change solutions, there is a simple and elegant solution. And we achieved that in the work we did with the House committee in a three-pronged approach that said energy intensive industries need assistance through allowance allocations during the early years of the regime.

Then we need to have a push to have international sectoral agreements, and we need to frame that up and urge our negotiators and the world's negotiators to take part in trying to solve these industry by industry in the energy intensive trade exposed industries. And if that does not work, then we need to have a date certain at which border adjustments would back stop that effort.

And if we do that, we are creating a system that allows us to go forward with great confidence that American industrial workers who are among the cleanest of producers of products in the global economy, that has been stated and I wholeheartedly agree with that, that those workers can participate in the global economy, produce the products that we need to build a clean energy infrastructure in this country, and do so with the assurance that their jobs are going to continue on into the future.

Senator SPECTER. Thank you very much.

Thank you, Madam Chairwoman.

Senator BOXER. Thank you, Senator Specter.

Senator Barrasso.

Senator BARRASSO. Thank you very much, Madam Chairman.

I would like to continue a little bit talking about some of the impacts on the economy, and Mr. Klesse, if I could, you know, I appreciate your testimony today. It is good to hear from folks really on the ground who will feel the impact of this cap-and-tax scheme first hand.

Green jobs are being touted as our economic salvation, but I believe we need all the jobs, green jobs as well as the red, white and blue jobs that power our country. I do not think we ought to be here in this room picking winners and losers when it comes to American jobs.

I have concerns about the impact that this will have, the bill will have, on electricity consumers in the Rocky Mountain West. And in Wyoming, coal provides roughly 95 percent of our electricity.

I know Senator Inhofe already asked about mandates in this bill and what they were going to do to your power production costs. I believe you said they were going to be increased. Then he asked what was going to happen as a result of that in terms of, you know, the costs, would they be passed on directly to consumers, your customers, and you said yes, they would.

So, what do you see happening specifically in the Rocky Mountain West, places that are more reliant on coal? Are they going to be disadvantaged by this bill?

Mr. KLESSE. Well, I am in the oil business, the refining business. So coal is much harder for me to speak about. However, we agree on energy generation, power, that it should come from nuclear, coal, natural gas, geothermal where it can, solar if it is appropriate. But we should not be penalizing these core businesses.

When I speak, we have four USW unions, different locals, at our plant. When I speak to the rank and file people, they understand this issue very quickly. And even though the general, Leo Girard, has his coalition, very clearly the rank and file people are very concerned.

The refining industry is under stress. We have CAFE standards coming in, which is lowering the carbon footprint. We also have the RFS and those are, in fact, reducing carbon emissions. But they also then are affecting the domestic refining business and this type of legislation just compounds it.

But on coal, it is very difficult for me to give——

Senator BARRASSO. And then, the cost to the consumer as the result of all of this?

Mr. KLESSE. It has to go up. It is a tax, the tax will be passed through. I was going to say earlier, our total cash operating costs in refining, cash operating, are 10 cents a gallon. That does not include profit or depreciation. So this is a very low cost, very pennies business.

Senator BARRASSO. And Mr. Vassey, if I could, someone said that the new regulations and Federal spending to mitigate these greenhouse gas emissions are going to create new job opportunities for some sectors of the economy. But those jobs, I believe, are going to come at the expense of activity elsewhere in the economy.

So, in terms of your State of Virginia, what do you see happening, kind of 10 years from now, in terms of manufacturing and the expenses of that and the costs if this bill becomes law?

Mr. VASSEY. What we see, as we testified earlier, the companies that are in the global commodities business, those that are in paper, that is about 15,000 employees, Senator Inhofe, those that are in chemical and plastics, that is another 40,000. Those are the companies that are going to be in jeopardy because they will have options elsewhere.

But also, they have very limited margins, just like refining, that they have to work with, and any fluctuation in their supply chain or in their regulatory burden they cannot pass through. Customers will not pay it.

The other things that I will share with you, we see decline in that, which is not good. We do not see immediate replacement with this provision. There needs to be some address to that. The other thing in my testimony, I said that just the threat of this coming will have immediate consequences.

And to your question about coal, we had a meeting this week with some of the coal producers, and we have now learned, which I would encourage the committee to review, many of the independent coal producers in Appalachia are being brought out by Eastern European companies for the express purpose that they are looking down the line and trying to preserve their family, their particular investment.

But the Eastern Europeans, as we understand it, see this as an opportunity that the United States is going to cap and trade their economy, but they will have access to raw materials so they can be the steel producer of the world in Eastern Europe. I think that is something worth knowing, that acquisition of American companies.

Senator BARRASSO. When you used the phrase opportunities elsewhere, you were not talking about cross-State border, you were talking about jobs moving, leaving the country and going overseas. Is that a correct assessment of your evaluation?

Mr. VASSEY. We do not see these companies as non-competitive. That is not the issue. The issue is that their margins and their pricing for consumer products they simply cannot pass along. So, they will find a place. They will find a way, they always have, to produce and sell in this economy.

Senator BARRASSO. Thank you.

Thank you, Madam Chairman.

Senator BOXER. Senator Whitehouse.

Senator WHITEHOUSE. Thank you, Madam Chair.

Mr. Vassey, I was delighted by the focus of your testimony on the problem of leakage and the promise that I hope that brings of the industry representatives paying more attention to the problem of enforcement.

I have detected a decidedly mixed message from industry on the question of trade enforcement because it has been so advantageous for CEOs and management to offshore jobs, find lower wage rates overseas, and it has not been in their best interests to push very hard at the fact that those overseas jobs often violate environmental laws and treaty requirements, labor laws and treaty requirements, workplace safety laws and treaty requirements.

So, I see that David Foster is here. I know that the cost of the offshoring hits the labor community particularly hard as jobs gets picked out of America and moved by management to foreign countries to seek that labor advantage and the parallel advantages of that environmental law, bad labor law, bad workplace safety conditions.

And so, I am hoping that what we see here is the beginning of an industry-labor coalition that will take what had been our policy of conspicuous non-enforcement and change that and also work very hard to assure, as both of you wish to, to assure that this bill, when it goes forth, particularly including the package that comes out of the Finance Committee that relates to the border adjustments, is really tough.

And if we have to tangle with the WTO a little bit on this subject, I am perfectly happy to do that. But this is, I just wanted to make that point. Both of you are here. It is not often that industry and labor are in such apparent agreement, and I wanted to take a moment to highlight that, and I will give you a chance to make a brief comment on that if there is time.

But I wanted to ask Dan Reicher something, which is that we have talked a lot about the smart grid, and smart grid has become jargon to a lot of us who are very familiar with these issues.

Google is a very forward looking company. You have a very forward looking position in that company. I would like to ask you to take a few minutes to try to make real for people who may be watching some of the kinds of changes that might happen in the middle class American home, that people might see as the consequences of smart grid and how that will work itself out in the lives of consumers.

And the core area of that question is what kind of products might we be building here in America to make those new services, technologies, appliances possible?

Mr. REICHER. Thank you, Senator Whitehouse. First of all, the smart grid seems to mean a million different things to a million different people. But I think, when all is said and done, what it does is it gives people a lot better information about their own energy use, whether it is in their home, in their factory, in their business.

And I think where energy technology and information technology, ET meets IT as we put it, where that intersection is, we can do so much, I think, to deal with some of the problems we are talking about today, to lower the costs of energy use, to green up energy supply. There is so much we can do.

And at Google we are very, very excited about it. We have launched a product, we call it Google Power Meter, we give it away for free. It is a piece of software, and it lets people know in near real time how much electricity they are using in their home. You can go on your smart phone, you can go on your laptop. I have provided some handouts today that will show you what you get. But when you go on your laptop, you go to the home page where you might show your stocks and your weather and the sports scores, and you will also see how much electricity you are using in real time.

And it is quite extraordinary what people discover. One of my colleagues found out that he was paying for the washers and dryers in his apartment building. Another discovered what that second refrigerator in the garage with the one six-pack of beer in it was really costing him. Another woman discovered that the pump in her pool had been operating non-stop for years.

The electric motor in my furnace, I did not realize that it was 40 years old, and every time it popped on I was hitting 1,000 watts. The furnace person said do not bother replacing your furnace, it is not worth it. Replace that little electric motor and you are going to dramatically cut your electricity use.

So it is quite extraordinary. And when we get to the biggest appliance in the house, which is the plug-in vehicle which is on its way, what we are going to be able to do with the integration of that into the grid is quite extraordinary.

What we do not want to do is be plugging in millions of these cars of a hot day in the summertime at the same moment and taking the grid down. What a smart grid will allow us to do is figure out when those cars should best charge up over the evening into the next morning. They will allow us to store that intermittent electricity that comes from solar and wind that is problematic for various reasons.

So, Senator, I think this whole area of the smart grid is so exciting. And that is why it is companies like Google and Microsoft and on and on who are really seeing the opportunity here. So, have at it. I think the President yesterday announcing $5 billion in spending on advanced meters is really going to lay a good foundation, and I think this bill could do an awful lot more.

Senator WHITEHOUSE. Thank you, Chairman.

Senator BOXER. Thank you, Senator.

Let us see. We are going to Senator Udall, and next Senator Carper and then Senator Merkley, unless our other colleagues come back. Go ahead.

Senator UDALL. Thank you, Madam Chair.

Mr. Reicher, a little over 10 years ago, Google, as a company, was based out of a garage with only a handful of employees. Last year it had annual revenue of over $21 billion, triple the amount in just 3 years.

Why would a company like Google, which has a successful business in advertising, in search engines and information technology, be looking at clean technology and energy efficiency as a new business opportunity? And what kinds of energy projects has Google already done in this area, and what kind of results does Google hope to achieve as a company and as a part of society?

Mr. REICHER. Thank you, Senator Udall.

First of all, you know, Google, those instantaneous searches that everyone has come to rely on in their lives, they do take some electricity. So, we recognize that. We have done a lot to green up and reduce the energy use in our data centers all over the country. So that was Google's entry point into this.

But I have to say, more importantly, this intersection I said between energy technology and information technology, we are quite convinced is really, really promising to help us deal with the big challenge we have as a country, and frankly, as a way to make some money for companies of all sorts.

So, as I said, we have launched this product called Google Power Meter. We have also built a fleet of plug-in vehicles, and we have been testing them for the last few years. And you know what? They actually work. They plug into a system at Google that, on a sunny day, is powered by the sun. Our employees use them in their day-to-day business, driving around Northern California. And they really have shown us that you can do so much with these plug-in electric vehicles.

So, we are convinced that this whole area of the grid and the net coming together holds such great promise for our country and for the world, and frankly, I think this bill provides some allowances for the smart grid, and we are very appreciative of that.

We think the R&D need is great, and we have to continue to invest in these kinds of technologies to move them forward. But all in all, it is a great package, and I think it is the good news in this whole story. Thanks.

Senator UDALL. To follow up a little on that, you have spent time in the energy sector and in the Department of Energy, and now you are really in this entrepreneurship venue. And so I wanted to ask you, with that background, when we hear Senators say, and the naysayers many of them, that we cannot achieve these goals, and we cannot get the reduction in terms of 20 percent by 2020, do you believe that American creativity and ingenuity and innovation are going to, when we put the signal in the market, the price signal out there, are we going to able to achieve many of these things earlier than we think?

Mr. REICHER. Absolutely. And it is curious, Senator, that this whole conversation this morning has really avoided what is really, I think, the low hanging fruit, which is energy efficiency. The low hanging fruit. And you know what? This is low hanging fruit that grows back. That old incandescent light bulb you replaced with the compact fluorescent you are going to replace again with an LED bulb.

So, there is great ability, here and now, to get the kind of savings that we need to deal with our climate emissions problem. So, I think we overstate the costs of meeting this important challenge, and I think we understate the opportunity that could come in growing some major businesses in this country.

So, energy efficiency is the place to start. But going beyond that, as you say, what is the innovation pipeline producing? It is producing extraordinary opportunities. We saw the kind of companies that just a couple of days ago the Energy Department announced it was investing in all over the country with a whole range of technologies that promise vast savings in terms of carbon emissions and energy savings.

I will highlight, and I think it is something that is very important to your State, is the whole opportunity with advanced geothermal. Not too many feet below the surface of the earth is just a vast, vast energy and increasingly we know how to drill down there at low cost, we know how to extract it.

It is a great complement for the oil and gas industry because they know how to get to those depths. So, let us put these industries together. Let us put geothermal and oil and gas together and really take advantage of what is a highly attractive energy source and one, frankly, that is base load. It is 24 hours a day, 365 days a year, and increasingly it is on a very impressive price trajectory.

Senator UDALL. Thank you. Thank you to all of our panelists. And thank you, Madam Chairman.

Senator BOXER. Thank you.

Senator Voinovich.

Senator VOINOVICH. Thank you, Madam Chairman.

I have heard a lot of—I am sorry I did not hear you, Mr. Vassey. But Mr. Vassey, have you ever talked to Mr. Foster?

Mr. VASSEY. No, sir.

Senator VOINOVICH. Mr. Foster, some of the things that you talked about in your testimony, your concern about manufacturing and the allowances and how it works, and you have got some recommendations on how we can improve this piece of legislation. I would assume your concern that the allowances in the bill are not enough to take care of manufacturing, that the cost of energy will be passed on to your members, and therefore, it is going to cost them more to do business.

What I am concerned about here, the big picture, is this. The allegation is that we need cap and trade and set limits on emission so that we have the incentive to get people to do things that they ordinarily might not want to do.

From what I have heard here, Mr. Brehm, you have gone forward and done some very unique things working with a couple of businesses in Ohio. The question I have is, did you take advantage of any of the programs that are available in the Department of Energy for you do to this, or did you do this on your own?

Mr. BREHM. Senator, a combination. We are a recipient of a number of grants from the DOE, from the department that Dan used to run, Energy Efficiency and Renewable Energy. In fact, we are working on some of those R&D projects with companies in Ohio, and we are working on some of the production and the manufacturing with companies in Ohio which were more done with private funds. But a combination.

Senator VOINOVICH. The concept of the bill is that we charge for allowances, that raises money, and there is more money for incentives. The question I have got is that if we concentrated on the incentive part of this, would we not be far better off than to create a gigantic new process where we give out allowances, or we pay for allowances and so forth, and really got at the real issue here, and the issue is technology.

And everybody analogizes, I do not know if you are familiar with this, with the Clean Air Act which had the acid rain provisions, and I was familiar with that as Governor at Ohio. At the time we put that into effect, there were 15 years of work to deal with NO_x-O_x, mercury, we were not talking about greenhouse gases. And we were able to move forward with it.

The problem, as I see it big picture-wise, is we do not have the technology in many of these areas. Mr. Klesse, for example, you get 2 percent of the allowances, you have got 44 percent of the problem. How do you reconcile some of these things? If he gets 2 percent of the allowances, they raise the cost of gasoline, that is passed on to the people in Ohio, and they provide the allowances, so they provide the money for the incentives for you to do what you want to do. And it just seems like we are just kind of going around in a circle.

Mr. Klesse, I will just ask you this. What is your solution to this? I understand that refineries, you guys are going to stop refining oil here, you are going to get it refined overseas because of the cost. Even if you do that, you are still going to pass a big cost on to your customers. What is the solution to this? How do you deal with this?

Mr. KLESSE. Well, we see this program as very unfair to this industry. We already have CAFE standards coming in, the RFS, renewable fuel standards, in, so we see these things happening. We also are supportive. I agree with the comments on efficiency. There is tremendous opportunity in efficiency. When I started working as an engineer, we had an investment tax credit. We could have a lot of positive initiatives here to encourage industries, smart grids, all of those, to make investments to improve efficiencies.

But this bill is inherently unfair, penalizes the refining and oil business directly, and is legislatively picking winners and losers.

Senator VOINOVICH. I would just like to comment, too, that I introduced a bill with Senator Dorgan called the National Energy Security Act. And one of the biggest things we talked about was the grid. And Mr. Reicher, you talked about the grid. Now, we are putting $3.5 billion into the grid. Most people say if we really want to do the grid, we are probably going to have to spend $60 billion to do it the right way.

I guess that, from my perspective, maybe our priorities are not in line. And Mr. Foster, I want to call you afterwards and talk to you about what your group is concerned about. Because I think there are some things here that could be reconciled, where we could come up with something that would move us forward but not get us engaged in a large system where we are collecting allowances, paying for allowances, giving allowances away and end up with a set up that raises, increases everyone's costs, and does very little to really reduce the emissions.

Mr. REICHER. Senator, if I could very quickly. You said——

Senator BOXER. Make sure to answer quickly because we are running out of time.

Mr. REICHER. You said technology is the issue. Technology is part of the issue. But until we put a significant price on carbon emissions that really reflects the true impacts they are having on the global climate, we are not going to drive the kind of change that we need.

It needs to be a combination of technology and policy if we are going to see the sort of changes we need that are going to be both good for the economy and good for the environment. And that is what is behind this bill. And either EPA is going to do it, or the Congress is going to do it, one way or the other.

Senator BOXER. Thank you very much, Mr. Reicher. And thank you, Senator.

Senator Udall. I mean, Senator Carper. I almost gave you a second round.

Senator Carper.

Senator CARPER. One of the Toms. One of the Toms gets to go next.

Let me say, Madam Chair, it is a good panel. And some of these folks I have the privilege of knowing. It is great to see the Mayor of Philadelphia, our neighbor to the north. I understand there is a baseball team in Philadelphia. You are playing ball there very soon, we hope. Good luck. A lot of Phillies fans down in Delaware, as you know.

Mr. Klesse, has anyone ever mispronounced your name?

Mr. KLESSE. Yes.

Senator CARPER. Today? In the last hour, probably. Thanks for bearing with us. It is so nice to have you here. Valero is one of any number of companies that are going to refinery operations in Delaware City.

I came out of the Navy in 1973. I had been a naval flight officer. And I moved from California to Delaware and got a Masters in Business Administration. I took a course in my first semester, and I had to do a research project on a company that had problems, really, with the law. And Getty, at the time, owned the refinery in Delaware City and they had long standing problems with Clean Air Act compliance.

And I ended up, literally, in my first semester at Delaware, in my first months at the University of Delaware, doing a fair amount of research on the refinery there. There have been a lot of owners since that time. We think Valero actually is one of the better operators and the more responsible operators with more of an environmental conscience than some of the others. So, we appreciate that.

And I appreciate what you said earlier about—you have, I think you said, a 50-megawatt windmill operation at your headquarters, and I think you said you are also into ethanol, and we would welcome that kind of diversification. I hope your shareholders do as well.

I almost fell out of my seat, though, and I think my colleagues did as well when, I think you said to Senator Boxer, that it looked like you would be spending for your operations, your refinery operations in California, $850 billion in a year.

Corrected, you said $850 million in California in a year. And I have looked at your testimony, and I am up to page 3, and my staff here behind us has been trying to help me figure new on some numbers, and I just want make sure we got this correct.

I will just quote your testimony. It says industry-wide, we estimate the compliance costs for process emissions with carbon at $20 a ton to be $4.1 billion a year. And that is, I think, nationwide, I believe in a year, for all refineries. And your portion of that would be, I suppose, less than maybe one-quarter. But in any event, I presume that is what we are talking about industry-wide, $4.1 billion a year. You estimate the costs of consumer emissions to be about $63 billion a year, for a total cost to domestic refiners, and potentially to consumers, of more than $67 billion a year.

That is a lot of money. I think we all agree with that. And I ask myself, well, figure out for us, if you can, how much gasoline and how much diesel fuel do we use when we drive our cars and trucks and they came back and said about, today, about 450 billion gallons of gas and diesel refined and consumed annually.

If I do my math right, and I divide 450 billion gallons into $67 billion, it works out to, I am told, somewhere between 13 and 15 cents per gallon. I think that is a correct number. And I am told this is by 2020.

When I heard this $850 billion number, I was real price sticker shocked. When I think of 13 to 15 cents per gallon by 2020, I just want to say we can remember back only a year or so ago when we saw such price volatility that the price of gasoline in my State, and I think all of the States, probably went up by 13 cents per gallon in a month, maybe in some places in a week. And we are talking about an increase of 13 to 15 cents over the next decade, by 2020.

Are my assumptions reasonably correct? Is 13 to 15 cents per gallon pretty much on target?

Mr. KLESSE. If you use $20 per ton, and nothing else changes, then I would say your numbers are exact. But that is not what we expect to happen at all. Nor do any of these reports that are published, including the DLE. We have a wide range of numbers that go all the way up to $1.50 by 2019 or 2020. It depends on what you assume for the cost of carbon. In my number, it is $87 a ton.

Senator CARPER. Let me just ask the Chair a question, if I could.

Senator BOXER. Yes.

Senator CARPER. I have been told by others that the costs of carbon per ton will probably, initially, be less than $20 and eventually it is going to rise. Do we have a cap?

Senator BOXER. We do. We have a soft collar, as you probably know.

Senator CARPER. What is that? What does that mean, Madam Chair?

Senator BOXER. Well, it means that the bottom is $11 and the top is $28, and if it gets to $28, we have an allowance reserve fund where those allowances are sent out so we that we will not see prices over $28 because absolutely, and this is something we did, Senator Carper, if I can just say, this is something we did because industry was concerned about carbon going up too high, and also others were concerned about market manipulation.

By the way, I am going to add time on to you.

We also have the ability to go for offsets as well. So, I think, given all of that, I feel very good with that 13 cents that you quoted.

Could you just put Senator Carper back to a minute please?

Mr. KLESSE. Can I——

Senator CARPER. Let me just finish one more point because my time is limited. And I would welcome the opportunity to continue the conversation beyond this hearing.

But just doing the math, back of the envelope math, if we say 15 cents per gallon with carbon at $20 a ton, if we go up to $28 a ton, that would raise the price to roughly 20 cents per gallon. Does that sound like even wildly in the range of——

Mr. KLESSE. That does and those are correct numbers. However, this cap increases every single year. It has the ability to increase. We also do not think the allowances will be adequate.

A cap and trade program means anybody can trade. You and I can trade in this business. People will hoard them. We have seen this with the RFS and the renewable fuel standard where we have to buy RINs. RINs have gotten very high. It was never the EPA's expectation that RINs would get up to 18 or 19 cents a gallon.

So, these businesses, there are a lot of players and people act in their self-interest.

Senator CARPER. All right.

Mr. KLESSE. And the cap goes up every year.

Senator CARPER. Fair enough. Thank you for engaging this dialogue with us today, and I just look forward to continuing it. And again, to all of our witnesses, a lot of encouraging stories, including the launching yesterday of Fisker Automotive in——

Senator BOXER. I would like to——

Senator CARPER [continuing]. GM plant comes alive again, and we are going to be starting to build in a couple of years vehicles that will get 100 miles or so per gallon, and the plant hybrids, and we are going to be deploying the first windmill farm off the coast of Delaware, probably in about 3 years. And the idea here is to eventually have windmill farms up and down the East Coast to provide a powerful vehicle like the vehicle we are building here.

I still think there will probably be plenty of opportunity for our refineries to make a buck as well.

Thank you very much.

Senator BOXER. Senator, thank you very much.

So, here is what we are going to do. Our last questioner, we are going to shut it down after Senator Merkley and go to our next panel because we are running late.

Senator Merkley, please proceed.

Senator MERKLEY. Thank you very much, Madam Chair.

Mr. Reicher, you mentioned that Google is providing free software. I am assuming that I have to get a digital replacement for my mechanical electric meter to interface with that in some way?

Mr. REICHER. Senator, you have two options. You either get a replacement for your current meter, and there are many of those on the way or already arrived, and in fact, the money yesterday from the President is going to speed that up. Or even simpler, you can clip a little tiny device on your fuse box, and those are readily available as well. They are inexpensive. You do not even need the smart meter.

Senator MERKLEY. Is Google giving those away with the software?

Mr. REICHER. Not at this point.

[Laughter.]

Senator MERKLEY. You would have about a million calls after this hearing because——

Mr. REICHER. I will not announce that here.

Senator MERKLEY. I am sure a lot of Americans will find this a very interesting idea. I just wanted to publicize that a little bit. Thank you. What does one of those little clip on devices cost to put on your fuse box?

Mr. REICHER. The devices are, today, around $150. And we are expecting they are going to come down very significantly in price when they go to mass market.

Senator MERKLEY. Well, I am going to be calling my utility company and find out when I can get a meter or whether they are going to subsidize that cost. That is very helpful. When people start monitoring how they are using energy, they change practices. So, thank you for mentioning that.

I wanted to shift to the personal vehicle plan that is part of the overall Google energy plan. And I believe that personal vehicles now produce about 20 percent of the carbon dioxide in the U.S. economy. Is that a roughly accurate estimate?

Mr. REICHER. I do not know. It is in that range, but I do not know.

Senator MERKLEY. I believe transportation is about 60 percent of the carbon dioxide, and personal vehicles are about a third of that, I believe. So, I was going to pin you down a little bit on how much that particular piece of the plan would reduce the carbon dioxide produced in the personal vehicle sector. And you may not have a reading on that——

Mr. REICHER. Well, I will say, and Senator Alexander talked about replacing half the fleet with plug-in vehicles, if we move to do two things, increase our use of plug-in vehicles and green up the electric grid by whatever means from solar to wind to geothermal to nuclear and beyond, we will have very significant impacts in the personal transportation sector on greenhouse gas emissions.

Senator MERKLEY. At one point, I heard it described this way. And I think this is a little out of sync with the numbers in your studies, but I will mention it and have you give your version. It was that if we enable every vehicle, every vehicle, so at a 100 percent transition, if you will, to go at least 30 miles on electricity, that we would reduce 70 to 80 percent of the carbon dioxide produced by personal vehicles.

Does that fit, or do you have a different version of that statistic? I realize, in your plan, by 2030 we do not get to 100 percent doing the first 30 miles on electricity, but——

Mr. REICHER. It is in that range. And the difficulty in making the estimate is that you really have to know the state of the electric grid, how green is the grid at that point in time. But the faster we green up the grid, by whatever means, the more that the emissions from the personal automobile sector are going to go down.

But what is exciting about it is that it is a very efficient way to run a vehicle, and I think these hybrid gas-electrics will give people both the ability to lower their fuel bills but at the same time have some confidence that, you know, when that 30 miles on electricity is up, there is another several gallons in the tank that they can continue with.

Senator MERKLEY. Well, I want to really emphasize how much potential carbon dioxide savings are here. Because if we can reduce 70 percent of 20 percent, that is a substantial, substantial amount, about 14 percent of the carbon dioxide produced in our economy.

And if we look at it this way, this plan we are putting out right now aims to reduce 20 percent below the 2005 levels, but we are zeroing in on 9 percent already. So that means we really only have to reduce 1 percent per year over the next 11 years to meet our 2020 target. And here we are talking about just personal vehicles with the potential to reduce up to 14 percent.

So, you lay out three strategies. One is new sales, more and more new sales being plug-ins and full electric cars. A second is having the remaining conventional vehicle sales significantly increase their mileage from 22 to 45, which I think you note is the European standard for 2012. And the third is to accelerate turnover of the older cars.

In your vision, taking those theoretical goals, how do we convert, if we were to actually say let us set mileposts, and let us make those happen, what type of legislative strategy would be most effective?

Mr. REICHER. Well, I think, first and foremost, what this committee is focused on, which is put a significant price on carbon emissions, and do it by an efficient mechanism from a business perspective. I think that will dramatically drive change.

Second, the direction we are headed in terms of increasing the fuel efficiency standards for regular vehicles. I mean, I think third, if we are going to really accelerate the introduction of plug-in vehicles of all sorts, I think incentives can help. I think investment in battery technology which is the real rub here can help a great deal. And then I think making sure that we have got a grid that is able to charge up large numbers of these vehicles and getting that ready, I think, is the third.

Senator MERKLEY. Thank you very much. Our time is expired.

Thank you, Madam Chair.

Senator BOXER. So, Senator Sanders, you came in the nick of time.

Senator SANDERS. I was cheating. I was watching TV.

Senator BOXER. OK. Unless there is a Republican who comes in, if they do, I will give them time, we are going to move to the national security panel after Senator Sanders.

Senator SANDERS. Mr. Reicher, the State of Vermont, although Senator Boxer may argue with me, I think the State of Vermont is leading the country in terms of energy efficiency, and in fact, we are consuming less electricity now than we did a couple of years ago.

If the country was aggressive in terms of energy efficiency, how many jobs do you guess that we can create over a period of years?

Mr. REICHER. Well, Senator, first, Vermont has an exemplary record when it comes to energy efficiency improvements. It is a good race that Vermont has with California, frankly, so I applaud all that you are doing there and know some about what is going on.

In terms of job creation, another point that was not made today is that among the highest producing areas of energy in terms of job creation is, in fact, energy efficiency. You know, going in and retrofitting a home is real, real jobs, doing all the sorts of things to improve energy use in a commercial building or in a factory. Those are real labor intensive jobs. They are good jobs. They are jobs that the unions like. They are jobs that electricians and plumbers and builders really love.

So, the job creation potential in energy efficiency is extraordinary. We are talking hundreds of thousands. We are talking potentially millions of jobs. Just look at the low income weatherization program. The billions we are now going to be spending there over the next couple of years. Major, major job creation in areas of the country that desperately need it.

Senator SANDERS. Let me ask you this. Do you believe that this committee should require that allocations for electric utilities go at least, in part, to energy efficiency, just like allocations for natural gas?

Mr. REICHER. I do think that would be a wise improvement to the pending bill.

Senator SANDERS. OK. Let me ask Kate Gordon a question. And Mr. Mayor, you can jump in on this as well.

We spend, depending on the year, hundreds of billions of dollars a year importing oil from Saudi Arabia and other foreign countries. If, over a period of time, we invested those hundreds of billions of dollars in energy efficiency and sustainable energy in this country, wind, solar, geothermal, biomass and other technologies, in energy efficiency in mass transportation, do you have a guess as to how many kinds of jobs we could create?

Ms. GORDON. It is a tough question. We do know that jobs in transit, our transit investments create about nine times the number of jobs as similar investments, in new highways, for instance. And I think it is a critical point that we cannot just talk about the current amount that we spend on existing technologies. We have to talk about reducing how much we use technologies and moving to new technologies.

Massive investments in energy efficiency create jobs and bring bills down. Major investments in transit systems and in clean vehicle manufacturing, as are in this bill, bring driving times down, bring vehicle miles traveled down, make those miles more efficient, that has an impact on consumer costs just as great, if not more, than the amount that we spend on the technology.

Senator SANDERS. Mr. Mayor, let me ask you this. I mean, I think in Vermont, and I am sure in Philadelphia, most people do not think it makes a lot of sense every year to be spending hundreds of billions of dollars making the sheiks in Saudi Arabia a little bit richer. What do you think about that?

[Laughter.]

Senator SANDERS. I know that is a tough question. But you can go on the record here.

Senator BOXER. I hope that your team gets as many soft balls tonight.

[Laughter.]

Mr. NUTTER. All right, Senator. Thank you. We are looking forward to it.

Senator Sanders, first let me say thank you very much for the question and also your leadership with regard to the EECBG, and of course your previous service as a Mayor in Burlington.

The fact of the matter is, as a Mayor, I try to do my best to stay pretty focused on the narrow area of domestic policy. I do not get engaged in many conversations about what might be going on in Saudi Arabia.

But what I can tell you is that the city of Philadelphia owns 450 buildings and facilities. We want to retrofit every one of them. That is a job that cannot be outsourced somewhere else. You have to do that work right in our city. We are seeking to reduce our energy costs just for the city of Philadelphia by 30 percent through our Green Works Philadelphia Plan by 2015. That is real money.

Senator SANDERS. A 30 percent reduction?

Mr. NUTTER. A 30 percent reduction in our own city energy costs by retrofitting our buildings, making them smarter, more energy efficient and taking other steps. All of that work would have to be done in Philadelphia. Those are jobs right here in our city.

So, there will be thousands of jobs created through the green economy, whether it is by the work that we do. Earlier, in my testimony, I do not remember if you were sitting there or not, Philadelphia is a city of mostly row homes. We have 400,00 houses that pretty much have flat roofs or can certainly take solar panels, green roofs, white roofs, the Dow Chemical Company, which just took over Roman Haus, has materials that can be used for that application, those are all jobs in the city.

Senator SANDERS. Great. Thank you very much, Mr. Mayor.

Senator BOXER. I just want to say to the panel, to all of the panelists, from the majority witnesses to the minority witnesses, we greatly appreciate your time. You have been terrific, every single one of you and really helping us as we move this bill forward. Thank you very, very much.

So, we are going to go right to the next panel. I promised Senator Klobuchar. I just want to make sure everybody knows, if you get any questions from the committee, we need them at the end of close of business today, the answers. I do not expect you will. I have not heard of any. Do you have any? OK, there will be some questions. They have to be in tonight.

I am going to ask folks if they could depart because we have an extremely distinguished panel waiting to come in, Hon. John Warner, Kathleen Hicks, Vice Admiral Dennis McGinn, Major General Robert Scales, Drew Sloan, Lieutenant Colonel James Carafano.

Ladies and gentlemen of our next panel, we thank you so very much for your patience. I do have some good news for you. There will be no opening statements by Senators on this panel, so we are going to get right to the testimony. We are greatly honored by your service to country, by your presence here today, and for your willingness to help us tackle this very important issue.

Just for the rules, we are going to start with our esteemed Senator John Warner. And we are going to go straight down the panel. If you can keep your remarks to about 5 minutes, we would appreciate it. I am not going to cut you off if you go 30 seconds over, but then I will start tapping this little gavel only because we have two more panels today to hear from, and we want to get all of you in.

So, we will begin with someone who needs no introduction. I was mentioning, Senator, that I personally really missed you from this committed, and everyone has kind of agreed. But I was out there wishing you were sitting here once again.

Senator INHOFE. Let me echo her remarks, Senator Warner. We do miss you. And of course, he and I were on two committees together so we spent a lot of time together.

Senator BOXER. I know. Well, Senator Inhofe and I are in agreement on this, at least.

[Laughter.]

Senator BOXER. So, Senator Warner, please proceed.

STATEMENT OF HON. JOHN WARNER, U.S. SENATOR (RETIRED)

Senator WARNER. Well, thank you very much, Madam Chairman, and my long-time friend, Jim Inhofe. I can remember campaigning for you when you first ran for the Senate in your wonderful State. And other friends around this table.

I will tell you, when I look back, I spent half of my adult professional life in this U.S. Senate. And I hope that, when your time comes, that you feel as I do. It was worth every day of it. I miss it daily, but life, as Thomas Jefferson said, you have got to step off the path of public life and let those following behind take over. And that I do.

But I commend you on the hearing today. Seriously, I have been involved in this for some time. This was a good hearing. I mean good, constructive exchange of viewpoints and tough questions. And that is what is most severely needed.

So, unless you wish to give me the oath of office——

Senator BOXER. No, just please proceed.

Senator WARNER. But under the Ethics Law, I am permitted to accept your invitation which I do, most respectfully, to join you today. I shall be very brief. Hit that gavel at 5 and I will stop instantly.

I thought long and hard about what I might add today other than contribute my written statement. So, I just thought I would say what I have done since I last appeared before you.

First, I want to say how privileged I am to be with this distinguished panel. I cannot see all the way to the end.

[Laughter.]

Senator WARNER. I have appeared with many of them before on other panels and particularly my friend Vice Admiral McGinn here. Senator Inhofe, here is a top gun, and let me tell you, he has an extraordinary career in aviation like yours. And we fly by the seat of our pants. We have been to what, eight or nine States together, basically to carry forward, and listen to the people out there. It has been fascinating.

I would say that the American public has a high level of interest in this subject. And they are anxious to learn. And that puts upon those of us in our respective positions the obligation to help them learn so that they can formulate their own opinions and be a constructive part of the dialogue on this issue which is, in every respect, as complicated and as tough and as challenging as the health care issues before this august Congress today.

So, I have had that privilege to travel to the States. My basic message is the linkage between our climate global considerations, the desire for our country, and many, to try and seek higher efficiency use of their energy, new renewable sources, and the whole galaxy of issues that are coupled with energy. And last, how all that is tied in to our national security.

And members of our panel today, I am going to yield the floor to them because I have covered the subject with the committee, and I have some of it in my statement. But I think this is a chance for them to give a new perspective on it, and I am anxious to hear their testimony.

Very quickly, the Pew Foundation, which I basically work for, and the Center for Naval Analysis, which Admiral McGinn and I work on, had the concept that there is an awful lot of discussion going on in Washington, but we need to go out and listen a little bit and perhaps share with those in the States what we know about it back here and learn from them what they think they know about it and what they want to know in greater detail. And that we have done.

Then I want to commend the departments and agencies of the Federal Government under the leadership of the President and others. Madam Chairman and members of the committee, they are moving out. And you will hear a most impressive story about the Department of Defense. As you may recall, when our mutual friend, now Secretary of State Clinton, was on this committee, the two of us teamed up and on the Armed Services Committee put in the legislation requiring the Department of Defense to begin to work in their out year quadrennial 4-year projections of what the roles and missions might be of the men and women of the Armed Forces.

The bottom line is, that when we talk about national security, our thoughts are with them because when the President, as Commander in Chief, issues the order to go, be it a humanitarian situation like the tsunami or the fragile collapse of Somalia years ago, they are the ones that have to drive the airplanes, fly them to ships, bringing forth the platforms that lift capability to try and bring a measure of relief in the humanitarian situations and a measure of stability in those where sovereign nations are collapsing.

The intelligence community is doing a great deal of study on this. Admiral Blair, the Director of National Intelligence, recently said the intelligence community judges, and I repeat judges, it made a judgment, that global climate change will have an important implication on our U.S. security for the next 20 years. That is our top person in intelligence.

The CIA has originated its own program. And I must say, I went out and visited—I have worked with the CIA for all of the many, many, many years I have been here and when I was in the Department of Defense. It is not a spy mission. It is simply utilizing their vast array of collection devices to gather information, synthesize it, and let it be made known for the general public use as well as the policymakers and the Government. And I commend them, particularly Director Panetta, who has put this into going.

So, there is growing progress in our Government. Then there is growing progress in other nations of the world. I listened to the leakage issue, and that is a vital one. But at the same time we are confronting the leakage issue, we have got to be aware that nations are moving out and taking the positions which this country dominated for a number of years. For example, Japan is leading in batteries, Germany in photovoltaic cells, Korea in the components for nuclear power plants, Denmark the wind energy, and in China and India, pretty well across the board in all those things.

Now, they are investing in trying to get the solutions that the United States and other nations will need when they finally confront the issue of climate change and decide what they are going to do. I just generically say they are the black boxes, they are the silver bullets to help decide how we do sequestration, how we do the plug-in systems, all of those things.

They are out there putting that technology and putting the stock on their shelves. So, when the United States, and we will, as sure as I am sitting here, someday this country is going to move forward unifiedly, executive branch and legislative branch, and begin to temp our role in dealing with this. Those black boxes we will have to buy from the shelves in these nations.

So, I will yield the floor.

[The prepared statement of Senator Warner follows:]

Testimony of Senator John Warner (Retired)
Senate Environment and Public Works Committee
October 28, 2009

Madam Chairman, Senator Inhofe, members of the Committee, thank you for inviting me to testify here today on the critical issue of climate change. It is always a pleasure to appear before my former colleagues, and I do so within the post-employment restrictions that guide retired senators and allow them to be invited to provide testimony.

As you all know, in my retirement, I continue to work on an issue of great importance to me: the linkage between global climate change, greater energy independence, and national security. Over my thirty years in the U.S. Senate working with military men and women and their families, I left convinced that, if left unchecked, global warming could increase instability and lead to conflict in already fragile regions of the world. We are talking about energy insecurity, water and food shortages, and climate driven social instability. We ignore these threats at the peril of our national security and at great risk to those in uniform who must operate, on orders of our President, the sea lifts, the air lifts, and other missions to alleviate humanitarian suffering or sovereign instability in remote regions of the world.

I am pleased and honored to be part of several projects of the Pew Charitable Trusts, including the Pew Project on National Security, Energy and Climate and the Pew Center on Global Climate Change. I also work with a number of other very professional NGOs on this topic, including CNA's Military Advisory Board, the American Security Project, the Partnership for a Secure America, Center for Strategic and International Studies, and the Truman National Security Project.

The Pew Project brings together science and military experts to examine new strategies for combating climate change, protecting our national security, increasing our energy independence and preserving our nation's natural resources.

We recognized the need to take this message of the mutually-reinforcing goals of energy security, national security and climate security outside the beltway. We send teams out of Washington to different states, where we talk, but we also listen and learn from the public.

I have led these teams around this great nation, often joined by retired military officers, such as Vice Admiral Dennis McGinn of the Center for Naval Analysis. We have been working with state and municipal governments, colleges and universities, local organizations, and other local military, security and climate experts who join in our panel discussions with the public.

To date, we have visited Missouri, South Carolina, Florida, Michigan, Indiana, Virginia, Colorado, and Montana. In each of these states, teaming up with a member of CNA's Military Advisory Board, a local voice, and often members of academia, we have held a forum, open to the public to discuss this critical link between our national security, our energy security and climate change.

I had the distinct pleasure, on our last trip, of spending several hours at the U.S. Air Force Academy in Colorado Springs. Here I met not only with faculty, but with our nation's best and brightest future military leaders. And these young leaders get it. They understand the critical link, and their role in protecting this nation from the risks posed by changing global climate, including energy shortages, food and water shortages, and the future missions these young men and women will serve on to help.

In fact, the USAF Academy has established a most impressive framework of academic studies on this issue, as well as internal campus policies driven toward securing "energy independence" on the Academy grounds. By 2015, the Academy expects to produce all its own energy and hopes to serve as an example of how a vast infrastructure of buildings can not only save, but also produce, its own energy.

Numerous expert reports have documented the security challenges that global climate change could worsen. The Central Intelligence Agency's long-term forecasting arm, the National Intelligence Council, recently reported that global warming could directly impact the U.S. by threatening energy supplies, damaging military bases, increasing food and water shortages and stressing the economy.

In Congressional testimony earlier this year, director of National Intelligence Dennis Blair said "the Intelligence Community judges global climate change will have important and extensive implications for U.S. national security interests over the next 20 years."

In fact, recently, the CIA launched its Center on Climate Change and National Security. Last week I visited the Center and was most impressed. The Center is a small unit led by senior specialists from both the Directorate of Intelligence and the Directorate of Science and Technology. The new Center will bring together expertise on an important national security topic—how environmental factors can impact political, economic, and social stability overseas and, how such instability will affect our own national security.

The focus of this Center is not the science of climate change, but the national security impact of phenomena such as prolonged droughts, rising sea levels, increased temperatures, population shifts, and heightened pressures and competition for scarce natural resources. The Center will provide critical information and support to both the public and private sector.

In 2007, as a member of the Senate Armed Services Committee, together with then-Senator Hilary Clinton, we added to the fiscal year 2008 National Defense Authorization Act language requiring the Department of Defense to consider the effects of climate change on DoD facilities, capabilities, and missions.

As a result, DoD is leading the way in becoming more efficient and effective in their use of energy and working to reduce their carbon boot print.

This provision of law requires future periodic revisions of long-range Department of Defense strategic plans to take account of the impact on U.S. interests of global climate change and vulnerable energy sources. I am so pleased to be joined on this panel by DoD Deputy Undersecretary for Strategy, Plans and Forces, Kathleen Hicks, who will advise the committee on the strong initiatives the Department is taking to implement the law.

Finally, I have observed that many American's see climate change as a threat to continuing their family traditions and they want Congress to act to preserve them. Last week I had the distinct pleasure of joining 13,000 hunters and anglers nationwide on a telephone conference to discuss their very real concerns about climate change. These are men and women who frankly love the land. These sportsmen and women practice traditions shared from generation to generation, and they are concerned about the impact climate change will have on the traditions they hold dear. I would ask this committee to make sure they receive a fair portion of the allocation system to address the natural resource adaptation needs of this great nation.

If the U.S. does not get in front now, we risk ceding the technology ground to China and other nations that are investing in renewable energy, investing in research and development at a much faster pace than we are. We have a chance to not only reduce CO_2 emissions, but to help move our economy in the right direction and to create new industries and jobs here at home. We can help revitalize our manufacturing base, but not if we end up having to buy what I call the "black box" that represents the "silver bullet" technology from China. If that is not a reason to act now, I do not know what is.

Madam Chairman and members of the committee, I commend you for your efforts and continued leadership. As we say in the Marines, your bill has established a beachhead. Now is the time for Congress to move forward and provide a legislative framework that clearly establishes a role for the U.S. as a leader.

We need this Committee to take action because climate change threatens what Americans value: our young men and women who defend this country, our traditions, and economy. We must take the opportunity to reshape our failed energy system and create new jobs for our families.

To end, I would just like to thank the committee for having me here today and wish you luck as you move forward in the legislative process.

Environment and Public Works Committee Hearing

October 28, 2009
Follow-Up Questions for Written Submission

Questions for Warner

Questions from:
Senator Amy Klobuchar

1. The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

Answer: The impacts of sea level rise, floods, and changes in temperatures are having politically destabilizing effects. For example, water shortages and droughts drive mass migrations of people; result in scarcity of water and food supplies, often driving conflict over those scare resources; and provide breeding ground for extremist behavior. In Congressional testimony earlier this year, director of National Intelligence Dennis Blair said "the Intelligence Community judges global climate change will have important and extensive implications for U.S. national security interests over the next 20 years." The situation is serious enough that the CIA recently opened the Center on Climate Change and National Security as the focal point for its work on the subject. The Center is a small unit led by senior specialists from the Directorate of Intelligence and the Directorate of Science and Technology. The purpose of the Center is not to focus on the science of climate change, but the national security impact of phenomena such as desertification, rising sea levels, population shifts, and heightened competition for natural resources. The issue of climate change is serious, and the reaction of the intelligence community in preparing and responding for this risk is telling.

2. In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions of the world. In South Asia, India's rivers are vital to sustaining agriculture and Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position to deal with or prevent this type of instability?

Answer: As a whole, the Kerry-Boxer bill would put the U.S. in a better strategic position to deal with instability in the world by putting the U.S., as the historic largest emitter and largest per capita emitter, on a path toward reducing its greenhouse gas emissions. In terms of specific provisions that will help manage or prevent instability abroad, resources for technology transfer and international adaptation will help alleviate some of the issues that serve as "threat multipliers" and put these instable nations on the front lines of climate change.

3. Yesterday, the Department of Energy announced the University of Minnesota received a grant for producing motor fuel directly from sunlight, water, carbon dioxide, and bacteria as part of a grant through the Advanced Energy Research Program for Energy (ARPA-E). ARPA-E is based off of the Defense Department's classified research and development program known as DARPA. The Kerry-Boxer bill increases funding for ARPA-E and provides it with a dedicated funding stream. Undersecretary Hicks, can you explain what this program has meant to the Defense Department and any thoughts you have about the Department of Energy's equivalent?

Answer: In 2007, I was moved to add language to the FY2008 National Defense Authorization Act after hearing from several distinguished retired military personnel, many of whom serve on the Military Advisory Board of the Center for Naval Analysis, about the severe impacts global climate change was having and would continue to have on U.S. armed forces.

Questions from:
Senator David Vitter

1. Are you concerned about the loss of domestic oil, gas, and refining capacity in the U.S. under Kerry-Boxer?

Answer: I am not concerned about the loss of domestic oil, gas and refining capacity in the U.S. under Kerry-Boxer, but I am concerned about the direction of our nation's energy policy if we maintain the status quo. I would support a bill that not only imposed a cap on greenhouse gas emissions, but which provided for a broad range of policies to increase domestic energy production.

2. Do you understand that China and Russia have no intention of reducing their emissions?

Answer: It is not my understanding the China and Russia have no intention of reducing their emissions. In fact, in recent years, China has adopted a suite of clean energy policies and is taking concrete actions to advance to a low-carbon growth path.

3. Is it advisable to give the Chinese and Russians greater leverage over the U.S. economy?

Answer: It is not advisable to give the Chinese and Russians greater leverage over the U.S. economy, which is why the U.S. cannot continue to cede ground on the clean energy technology market to other nations. The policy decisions that lawmakers make - or don't make - will determine what the share of the clean energy market the U.S. will hold. China is spending $244 million a day on clean energy, while the U.S. has fallen behind. Enacting climate legislation will not only reduce greenhouse gas emissions, but it also has the potential to reinvigorate our manufacturing base and transform our economy.

Senator BOXER. Thank you, Senator, very much.

Our next speaker is Kathleen Hicks, Deputy Under Secretary of Defense for Strategy, Plans, and Forces, United States Department of Defense. Thank you very much.

STATEMENT OF KATHLEEN HICKS, DEPUTY UNDER SECRETARY OF DEFENSE FOR STRATEGY, PLANS, AND FORCES, U.S. DEPARTMENT OF DEFENSE

Ms. HICKS. Thank you, Senator Boxer, members of the committee, ladies and gentlemen. It is an honor to appear before you today to testify on DOD's views on how climate change relates to U.S. national security.

As the Deputy Under Secretary of Defense for Strategy, Plans, and Forces, I am responsible for advising the Under Secretary of Defense for Policy and the Secretary of Defense on all matters pertaining to the development of U.S. national security and defense strategy, including the ongoing Quadrennial Defense Review to which Senator Warner referred.

Let me begin by stating that DOD takes climate change seriously because of its significant implications for national security. Our strategic planning efforts look 20, 30, even 50 years into the future. We attempt to account for all factors that may affect how our military may be used and what capabilities we may need.

Climate change is a stress that has the potential to cause a rise in global temperatures, a rise in sea levels, an increasing frequency in severity of weather events, among other manifestations. These stresses carry with them clear geopolitical implications. Displaced populations, contributing to border tension and increased conflict, damage to agriculture posing risk to food supplies, and an increased global demand for humanitarian and disaster relief operations place a potentially serious burden on the U.S. military and international forces.

The effects of climate change are characterized by a degree of variability and uncertainty for a range of forecasting and modeling scenarios. Although specific climate change effects and outcomes cannot be predicted with accuracy or certainty, there are general trends in climate change that are reasonably expected to occur and that, out of prudence, we must account for in planning and conducting DOD activities.

Even under the most modest predictions, climate change will aggravate existing trends of population growth, dense coastal settlement, resource scarcity, poor governance and environmental degradation. Absent significant forestalling of climate effects, DOD's requirement to support civil authorities and contingency responses, both domestically and abroad, is likely to grow.

DOD also recognizes the strong linkage between global energy consumption and climate change. We cannot address one without impacting the other, and both have operational and economic consequences. Our dependence on traditional nonrenewable fuel sources constitutes a liability for our forces worldwide. This necessitates that a sizable portion of our force structure is dedicated to just keeping gas tanks topped off, and that instead of spending money on our people and on developing new capabilities, we are buying and burning fuel to haul fuel.

In the more distant future, as hydrocarbons grow more scarce and world demand continues to grow, the competition for upstream sources also increases, carrying with it the potential for conflict. U.S. Joint Forces Command General James Mattis has spoken from his field command experience in Iraq of the need to unleash us from the tether of fuel.

In mountainous underdeveloped terrain such as U.S. and allied forces face in Afghanistan, the need for fuel for everything from diesel generators to keep our modern war fighting systems up and running to the energy needed to power armored MRAF vehicles is a daunting logistical challenge and puts our soldiers, sailors, airmen and marines at greater risk as enemies target our logistics tail.

If we could free ourselves from the tether of nonrenewable fuel sources, we could greatly improve our war fighting agility. Alternative sources of energy have significant add-on implications for stabilization and reconstruction activities as well where providing energy to the local populace has been a continued challenge. Failure to provide for basic population needs can undermine the legitimacy of U.S. assistance efforts and host nation governments.

DOD is the single largest energy consumer in America. It accounts for nearly 1 percent of the Nation's energy use and nearly 80 percent of the Federal Government's consumption. DOD's energy use is roughly on par with Nigeria and Bangladesh, which have populations of 140 million and 150 million respectively.

With military installations across America, operating bases throughout the world, and the significant requirement of combat forces, powering the military is both an immense task and an immediate problem that has a direct impact on our ability to fight wars today.

As the largest consumer, we have a responsibility to be the smartest. DOD has long been a source of innovation for the United States.

In conclusion, as climate sciences advance and new observations give us fresh insights, we will regularly reevaluate climate change risks and opportunities in order to develop policies and plans to manage its effect on DOD's operating environment, missions and facilities.

Managing the national security effects of climate change necessitates that we work collaboratively through a whole of government approach with both traditional allies and new partners.

Thank you.

[The prepared statement of Ms. Hicks follows:]

Statement of Deputy Under Secretary of Defense for Strategy, Plans, and Forces
Kathleen Hicks
Before the
Senate Environment and Public Works Committee
Full Committee Hearing

Senator Boxer, Members of the Committee, Ladies and Gentlemen, it is an honor to appear before you today to testify on how the Department of Defense believes that climate change relates to national security.

The 2008 National Defense Strategy directs DoD to take into account how the interaction of areas of uncertainty, such as population growth, resource constraints, environmental and climate change pressures, may generate new security challenges. It recognizes that managing security risks will require managing the divergent needs of massively increasing energy demand to maintain economic development and the need to tackle climate change. Collectively, these developments pose a new range of challenges for states and societies.

We are in the midst of a sea change in understanding of the interrelationship between climate change and energy, and their impact on national security. In a speech to the Association of American Universities in April 2009, Secretary Gates included climate change among the sources of the security challenges we face today. Likewise, the Under Secretary of Defense for Policy, Michèle Flournoy, cited global climate change as one of the main trends that make security challenges more difficult and complex.

Under Secretary Flournoy has described how national security challenges are fueled and complicated by a number of powerful trends, such as the global economic downturn, prospects of climate change, cultural and demographic shifts, growing resource scarcity, and the spread of potentially destabilizing technologies, that are fundamentally reshaping the international landscape. She identified climate change as a stress that has the potential to accelerate state failure in some cases, and may also lead to the spread of insurgency as weak governments fail to cope with its effects.

DoD has a number of partnerships across the Federal government related to climate change. For example, DoD supports the National Oceanic and Atmoshperic Administration (NOAA) through data sharing and, in partnership also with the U.S. Coast Guard, in operating the National Ice Center. DoD is one of thirteen departments and agencies that participate in the U.S. Global Change Research Program, which coordinates and integrates federal research on changes in the global environment and their implications for society. The report released by the U.S. Global Change Research Program Office this past summer on the impacts of climate change on the United States noted that "in an increasingly interdependent world, U.S. vulnerability to climate change is linked to the fates of other nations. For example, conflicts or mass migrations of people resulting from food scarcity and other resource limits, health impacts, or environmental stresses in other parts of the world could threaten U.S. national security. It is thus difficult to fully evaluate the impacts of climate change on the United States without considering the consequences of climate change elsewhere."The U.S. Geological Service, within the Department of the Interior, receives DoD support in developing and sharing mapping information used in management of resources in a changing environment. The Department of Homeland Security (DHS) takes the lead in responding to requests for humanitarian assistance and disaster relief in the United States. DoD may support DHS with logistics assets and other capabilities as requested, depending on the location and circumstances of the disaster. The Department of State and the U.S. Agency for International Development (USAID) have leading roles in responding to requests for humanitarian assistance and disaster relief overseas, frequently with DoD support. Scientific projections lead us to believe that requests for DoD support to civil authorities for disaster relief will likely grow due to projected increases in the intensity, and perhaps the frequency, of extreme weather events such as severe storms, floods, and droughts. These are just a few examples of ways that DoD is engaged in supporting other agencies in responding to the challenges of climate change.

Climate Change Assessments

The 2008 National Intelligence Assessment of the Impacts of Climate Change, conducted by the National Intelligence Council (NIC), concluded that climate change will have significant geopolitical impacts around the world and will contribute to a host of problems, including poverty, environmental degradation, and the weakening of national governments. Climate change will contribute to food and water shortages, increase the spread of disease, and may help spur mass migration, though the causes of migration are complex and usually difficult to attribute to a single factor. The assessment warned that the storms, droughts, and food shortages that might result from a warming planet in coming decades would create numerous relief emergencies.

Recent scientific studies, including an assessment done by Oak Ridge National Laboratory in support of the Department's ongoing Quadrennial Defense Review (QDR), indicate that impacts of climate change will disproportionately affect regions with little ability to moderate potential damages or to cope with the consequences—in other words, regions with limited adaptive capacity.

In August the National Intelligence Council published a study entitled, "Global Climate Change and State Stability," which identifies countries that could become unstable from climate change in the near (2020-2025) and long (2040-2045) terms. Most of these countries are in the developing world. The report released by the U.S. Global Change Research Program Office this past summer on the impacts of climate change on the

United States noted that "in an increasingly interdependent world, U.S. vulnerability to climate change is linked to the fates of other nations. For example, conflicts or mass migrations of people resulting from food scarcity and other resource limits, health impacts, or environmental stresses in other parts of the world could threaten U.S. national security. It is thus difficult to fully evaluate the impacts of climate change on the United States without considering the consequences of climate change elsewhere." These studies represent only a few of the numerous assessments which hold that climate change will exacerbate the stresses which may lead to conflict.

The Quadrennial Defense Review

The QDR is examining the capabilities of the U.S. Armed Forces to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events and other missions the Armed Forces may be asked to support inside the United States and overseas, as directed by Section 951 of the National Defense Authorization Act of 2008. All of the Military Departments and numerous DoD components and agencies are participating in this effort.

As noted, DoD may assist other Federal Departments and Agencies in their missions by providing support to civil authorities. In this supporting role, DoD responded to close to 90 requests for assistance in the United States in 2008, ranging from hurricanes to wildfires. DoD is examining this issue of support to civil authorities closely in the current QDR. Similarly, DoD is examining its efforts to support the Department of State in responding to overseas requests for humanitarian assistance or disaster relief, such as it provided in the aftermath of the 2004 Asian tsunami. Effective response to such events has historically required a whole-of-government effort, often supported by international and nongovernmental organizations.

DoD's engagement role with the militaries of other nations enables DoD to promote environmentally sound technology and operational practices. In some nations, the military is the only institution with the capacity to respond to a large-scale natural disaster. Proactive engagement with such countries can help build their capability to respond to the needs of local or regional populations in event of a disaster. Theater Campaign Plans operationalize the Combatant Commander's strategy and provide the construct for focusing and prioritizing steady state activities as they relate to current operations, security cooperation, interagency and any preventative activities, which could include efforts to adapt to the effects of climate change.

Climate change adaptation will be part of the Department's long-term risk management strategy, in an institution that typically plans out to a 20-year time horizon and is accustomed to dealing with uncertainty. The effects of climate change are characterized by a degree of variability and uncertainty for a range of forecasting and modeling scenarios. Although specific climate change effects and outcomes cannot be predicted with accuracy or certainty, there are general trends in climate change that are reasonably expected to occur and can be considered in planning and conducting DoD activities. The military, after all, is an adaptable organization accustomed to operating in a wide variety of conditions.

Energy

DoD also recognizes the linkage between energy usage and climate change. We cannot address one issue without impacting the other, and both have economic consequences. Let us take an example from current operations. Attacks on the logistics tail in Iraq and Afghanistan have grown increasingly sophisticated and effective, resulting in a growing number of casualties. The capabilities of potential adversaries to attack our energy supplies and delivery forces through both conventional and asymmetric means will continue to increase. Taking steps to reduce our operational energy demand will not only improve our mission effectiveness, it will also reduce our carbon footprint.

In 2008 DoD spent $20.0B on total energy costs. $16B was for fuel for tactical systems. $3.95B was spent on "traditional" energy costs: electricity, natural gas, heating oil, purchased steam and coal. The remaining $0.05B was spent on transportation fuels for non-tactical vehicles. In 2008, DoD received 2.9% of its "electric" energy from renewable sources of generation. And, in 2008 DoD received 4.7% of its "total" energy from renewable sources of generation. The Department has reduced total "traditional" energy consumption by 10.7% through 2006-2008 using a 2003 baseline consumption year. The goal from 2006-2008 was 9.0%. DoD was 1.7% ahead of the goal.

To reduce our carbon footprint, DoD is rapidly moving forward to conserve and transition to more sustainable forms of energy. DoD has a goal of increasing its energy from renewable sources, and each of the services has a plan for energy-related initiatives in place. In the compliance arena, DoD made great progress towards achieving the goals of Executive Order 13423 (Strengthening Federal Environmental, Energy, and Transportation Management) on building efficiency and implementation of alternative fuel vehicles. DoD also looks forward to complying with the requirements of Executive Order 13514 (Federal Leadership in Environmental, Energy, and Economic Performance).

DoD Adaptation Initiatives

DoD is responsible for significant "built" infrastructure along the nation's coasts. This presents an opportunity to exercise good stewardship by engaging in a leadership role in local and regional adaptation planning. One example of this is the DoD Legacy Resource Management Program (Legacy). The Legacy program has begun to invest in national and regional efforts that will assist the Department in defining an adaptation strategy that will support the long-term sustainability of its natural and cultural resources. One of its projects is a partnership with the National Wildlife Federation, the Association of Fish and Wildlife Agencies, the U.S. Fish and Wildlife Service, and other federal agencies to develop a guidance manual that will summarize currently available natural resource-focused vulnerability assessment tools. Another example is an ongoing project to assess sea level rise scenarios on seven North Carolina military installations in order to aid decision-making regarding management of their natural resources and infrastructure.

During the past year, the Strategic Environmental Research and Development Program (SERDP) initiated four research projects focused on developing the methods, tools, and models necessary for DoD coastal installations to assess the potential impacts of sea level rise and associated storm surge phenomena on installation infrastructure. The four projects purposely address different geophysical settings, physical forcing mechanisms, and different degrees of vulnerability assessment to reflect that climate change impacts, and the information needed to assess those impacts, will differ greatly by geographic region. Knowledge gained through these projects and application of the resultant products will assist DoD installations in assessing potential impacts and using that information to develop adaptation strategies.

Military Department Initiatives

At the same time, the Military Departments are engaged in their own portfolio of activities that will support adaptation to climate change.

Climate change predictions in the southeast and southwest United States indicate a potential for more severe and extended drought conditions in those areas. The Army is evaluating current and predicted water use patterns on and near its installations in the United States, and comparing them to sources and predicted availability of water around these installations over the next 30 years. Currently ongoing at Ft Bragg, North Carolina, and Ft Bliss, Texas, the sustainable water assessment methodology is planned to be tested at an additional 10 U.S. installations and selected Army installations overseas. The Marine Corps is engaged in a similar effort for some of its installations.

The Navy established Task Force Climate change (TFCC) in May 2009. TFCC is chartered to develop a Roadmap for Navy action regarding the Arctic specifically, and climate change in general. This organization consists of representatives from the Chief of Naval Operations' staff, Fleet Forces Command, Navy Program Offices, academia, interagency partners, and research and development activities. It will make recommendations to senior Navy officers regarding investments in climate change adaptation, as well as associated changes in policy, strategy, mission, and plans.

The Office of the Deputy Assistant Secretary of the Air Force, Energy, Environment, Safety and Occupational Health (SAF/IEE) has established an Energy and Climate Change Issues Team with broad representation from Headquarters Air Force offices responsible for developing policies, plans and programs, establishing requirements, and providing resources for the entire Air Force enterprise. The team will assist the Air Force in developing plans and policies for adapting to the challenges posed by climate change by ensuring mission and operational impacts are considered across the Air Force.

Several climate change predictive modeling scenarios include an increase in the frequency and severity of wildfires in some geographic regions affected by climate change. In Southern California, the Marine Corps has initiated replacement of all above-ground communications and utilities lines with underground lines as much as economically feasible, to reduce vulnerability to fire damage.

Conclusion

As climate science advances and new observations give us fresh insights, we will regularly re-evaluate climate change risks and vulnerabilities in order to develop policies and plans to manage the effects of climate change on DoD's facilities, operating environment, and missions. DoD will also be monitoring and assessing the geostrategic implications of the social, political, and economic consequences of climate change. Climate change is representative of the kind of challenges highlighted by Secretary Gates in his opening statement to the Senate Appropriations Committee in May 2009—challenges that cannot be dealt with by military means alone, but that require a whole-of-government approach. DoD recognizes the need to plan for climate change and we stand ready to work collaboratively with traditional allies and partners to combat this challenge.

CHARRTS No.: SEPW-02-001
Hearing Date: October 28, 2009
Committee: SEPW
Member: Senator Klobuchar
Witness: Honorable Hicks
Question: #1

Question: The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

Answer: The 2008 National Intelligence Assessment of the Impacts of Climate Change, conducted by the National Intelligence Council (NIC), concluded that climate change will have significant geopolitical impacts around the world and will contribute to a host of problems, including poverty, environmental degradation, and the weakening of national governments. Climate change will contribute to food and water shortages, increase the spread of disease, and may help spur mass migration, though the causes of migration are complex and usually difficult to attribute to a single factor.

The conflict in Darfur between herders and farmers is a good example of environmental changes contributing to political destabilization. Long periods of drought resulted in loss of arable land and pasturage to the desert. In response, the nomads migrated southward in search of water and grass for their herds, which in turn led to conflict with the agrarian society occupying those lands. Coupled with population pressure, tribal, ethnic and religious differences, the change contributed to increased regional instability.

CHARRTS No.: SEPW-02-002
Hearing Date: October 28, 2009
Committee: SEPW
Member: Senator Klobuchar
Witness: Honorable Hicks
Question: #2

Question: In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions of the world. In South Asia, India's rivers are vital to sustaining agriculture and Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position to deal with or prevent this type of instability?

Answer: Analysis by the intelligence community indicates that climate change is a stress that has the potential to accelerate state failure in some cases, and may also lead to the spread of insurgency as weak governments fail to cope with its effects. A comprehensive energy strategy that reflects the current scientific understanding of the linkage between climate change and energy usage would contribute to national security over the long term.

CHARRTS No.: SEPW-02-003
Hearing Date: October 28, 2009
Committee: SEPW
Member: Senator Klobuchar
Witness: Honorable Hicks
Question: #3

Question: Yesterday, the Department of Energy announced the University of Minnesota received a grant for producing motor fuel directly from sunlight, water, carbon dioxide, and bacteria as part of a grant through the Advanced Research Projects Agency-Energy (ARPA-E). ARPA-E is based off of the Defense Department's classified research and development program known as DARPA. The Kerry-Boxer bill increases funding for ARPA-E and provides it with a dedicated funding stream. Undersecretary Hicks, can you explain what this program has meant to the Defense Department and any thoughts you have about the Department of Energy's equivalent?

Answer:
The Defense Advanced Research Project Activity (DARPA) is the research and development arm of the Department of Defense (DoD). DARPA has played an important role in DoD's ability to maintain a technological advantage over potential adversaries through the years since its founding. Its mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from threatening national security. DARPA funds unique and innovative research through the private sector, academic and other non-profit organizations, as well as government labs. DARPA research runs the gamut from conducting scientific investigations in a laboratory, to building full-scale prototypes of military systems. DARPA funds research in biology, medicine, computer science, chemistry, physics, engineering, mathematics, material sciences, social sciences, neuroscience, and more. DoD hopes that the new ARPA-E program will prove to be of similar value to the Department of Energy.

Senator BOXER. Thank you very much.

Next, another majority witness, Vice Admiral Dennis McGinn, U.S. Navy retired and a member of the Center for Naval Analysis Advisory Board.

Welcome.

STATEMENT OF VICE ADMIRAL DENNIS MCGINN, U.S. NAVY (RETIRED); MEMBER, MILITARY ADVISORY BOARD, CENTER FOR NAVAL ANALYSIS

Mr. MCGINN. Madam Chairman, Senator Inhofe and members of the committee, it is an honor for me to appear before you to talk about these critical national security subjects. I am here representing the CNA Military Advisory Board consisting of a dozen former Generals and Admirals representing all four services.

Let me start by summarizing some of our key findings from the two reports which you mentioned earlier, Madam Chairman.

First, our economic, energy, climate change and national security challenges are all inextricably linked. As Senator Warner said, you just cannot address one without taking into consideration the effects on the other.

Our past pattern of energy use is responsible, in a very significant way, for our economic situation today, not just nationally but globally. We therefore must make a long range comprehensive view to develop effective national policies and make real and positive changes in the ways in which we power America. A business as usual approach, continued over-reliance on fossil fuels, or small incremental steps simply will not create the kind of future security and prosperity that the American people and our great Nation deserve.

The time to act is now. And the time to act boldly is now. Without U.S. leadership and decisive action by our Nation, fierce global competition, instability and conflict over dwindling supplies of fossil fuels and increasing global warming will be a major part of the future strategic landscape.

Moving expeditiously toward clean and sustainable energy choices to power America can lessen that danger, improve global, national and sub-national economic security, and help us to confront the serious challenge of global climate change and energy insecurity.

If we do not address these challenges in a bold way and in a timely way fragile governments have great potential to become failed states and desperation and hopelessness will drive whole populations at a scale never seen before to be displaced. And this turmoil and power vacuum will create a fertile breeding ground around the world for extremism and the terrorism that surely follows.

The United States military will be called to respond to these new threats from humanitarian assistance and disaster relief up to the higher potential for regional war. As Secretary Hicks has pointed out, the Pentagon has already started to prepare contingency for such scenarios and will focus on the issue in its 2010 Quadrennial Defense Review, as will the State Department in its Quadrennial Diplomacy and Development Review.

At the same time, increasing demand for, and dwindling supplies of, fossil fuels will add greatly to instability created by climate change in many of the very same places that are worst hit by climate change. America's current energy posture constitutes a serious and urgent threat to our national security, militarily, diplomatically and economically.

We need to carefully avoid the temptation to ignore these connections and take only small steps to address narrow issues. Large, interconnected security challenges require bold comprehensive solutions. We must recognize that we, as a Nation, are at a pivotal moment in history. Those who say that now is not the time to act fail to recognize the gravity and the urgency of our energy and climate change challenges.

But they also, as was pointed out by the previous panel, fail to recognize the tremendous opportunity. There is a new multi-billion dollar revolution in clean technology around the world, and there is compelling evidence that clean energy policies are powerful economic drivers and energy efficiency, being the cleanest fuel that never need be mined, drilled or burned, and it represents a barely tapped resource that holds enormous power for all economies around the world.

The same is true for a whole host of clean and sustainable energy choices. There is a general agreement that there may not be a silver bullet to meet our growing energy needs, but surely there is a lot of silver buckshot that can be used to constitute a viable portfolio of energy sources that are not reliant on greenhouse gas producing feed stocks or processes.

Most importantly, America's leadership and key partnerships around the world in addressing these truly global challenges will act as a powerful catalyst for international collaboration to better address a whole host of pressing issues. The United States has an opportunity and an obligation to lead.

We can, as America has in the past, address the most pressing issues of our time. Through thoughtful dialogue, effective leadership and united action we can transform daunting challenge into sustained security and prosperity across the Nation and across the world.

Thank you, Madam Chairman, and I look forward to your questions.

[The prepared statement of Mr. McGinn follows:]

Statement of Vice Admiral Dennis McGinn, USN, Retired
Member, Military Advisory Board, CNA
before the
United States Senate
Committee on Environment and Public Works
Legislative Hearing on S. 1733
Clean Energy Jobs and American Power Act
Washington, DC, October 28, 2009
9:30 a.m. 406 Dirksen Senate Office Building

Chairman Boxer, Senator Inhofe, Members of the Committee, it is an honor to appear before you today to discuss the critically important topics of energy, climate change and international security.

As I stated in previous testimony before this Committee in July of this year, I have had the privilege of serving with some of America's most distinguished and senior retired military leaders on the CNA Military Advisory Board, which produced two reports directly related to the topic of this hearing. The first examined the national security threats of climate change, and the second report analyzed the national security threats of America's current energy posture.

We are just beginning to emerge from one of the most serious global financial crises of our lifetimes. This understandably focuses our attention on near term fiscal issues. However, after several years of examining climate change and the United States' energy use, it is clear to our Military Advisory Board that our economic, energy, climate change and national security challenges are inextricably linked. And it is also clear that our past pattern of energy use is responsible, in a significant way, for our economic situation today. For these reasons, we must take a long range, comprehensive view to develop effective national policies and make real and positive changes to the ways in which we power America. A business as usual approach, continued over reliance on fossil fuels, or small, incremental steps, simply will not create the kind of future security and prosperity that the American people and our great Nation deserve. The time to act, and act boldly, is now.

Weakened economies have temporarily reduced global demand and the cost of oil. However, as this recession ends, the volatile and economically disruptive cycle of ever-higher energy prices will most surely return. Population growth and projected per capita increase in energy consumption over the next twenty years will surely make fossil fuel supply and demand curves divergent unless we change our energy posture.

This is a critical and long term international security issue – one that stretches across geographical boundaries, over political divides, and one that will be with us for decades to come. Without national leadership, enlightened policies and decisive action by our nation, fierce global competition, instability and conflict over dwindling supplies of fossil fuels and increasing global warming will be a major part of the future strategic landscape. Moving expeditiously toward clean and sustainable energy choices can lessen that danger, improve global, national and sub-national economic security and help us to confront the serious challenges of global climate change and energy insecurity.

I will now briefly discuss those challenges.

The CNA Military Advisory Board produced a report in 2007 called *National Security and the Threat of Climate Change*. Its principal conclusion is that climate change poses a serious threat to national security by acting as a "threat multiplier" for instability in some of the world's most volatile regions.

Climate change is different from traditional military threats, because it is not like having a specific enemy, well-defined response timeline, or crisis spot we're trying to handle. Climate change has the potential to create more frequent and intense natural and humanitarian disasters due to flooding, droughts, disease, and crop failure. It will magnify existing tensions in critical regions, overwhelm fragile political, economic and social structures, causing them to fracture and fail. The predictable result: much greater frequency and intensity of regional conflict and direct threats to our United States' interests and national security.

Some may be surprised to hear former generals and admirals talk about climate change and clean energy, but they shouldn't be. In the military, you learn quickly that reducing threats and vulnerabilities is essential, well before you get into harm's way. As military professionals we were trained, and learned by hard experience, to make decisions when faced with seriously threatening situations, even when they were defined by ambiguous information. But in this case, the information is not as ambiguous as some may want to believe. The science community has clear consensus in concluding that human activities are the most significant cause of climate change. There is no disagreement in peer-reviewed literature. Every major professional science society and organization in the world has issued powerful statements to this effect, including the National Academies of Sciences for every major country. The G8 and 5 other nations said in May "The need for urgent action to address climate change is now indisputable."

As military leaders, we base our decisions on trends, indicators and warnings, because waiting for 100% certainty during a crisis can be disastrous. And as we carefully consider the threat of climate change and energy to global security, these trends and warnings are clear.

Two years ago, the Intergovernmental Panel on Climate Change – the world's leading scientific panel on climate change – including more than 200 distinguished scientists and officials from more than 120 countries, including the U.S. – predicted widening droughts in southern Europe and the Middle East, sub-Saharan Africa, the American Southwest and Mexico, and flooding that could imperil low-lying islands and the crowded river deltas of southern Asia.

Last month, global climate researchers revised those predictions, now forecasting that the planet could warm by as much as 6.3 degrees Fahrenheit by the end of the century even if the world's leaders fulfill their most ambitious climate pledges, a much faster and broader scale of change than the IPCC forecast just two years ago.

Their other findings include that sea level could rise by as much as six feet by 2100 instead of 1.5 feet, as the IPCC had projected, and the Arctic Sea may experience an ice-free summer by 2030, rather than by the end of the century.

Let me give you some examples of what the future could be like if we fail to adequately address the causes and effects of climate change.

In Africa, projected rising temperatures will dramatically reduce water availability, soil moisture, arable land and food production. Combined with increased extreme weather events – climate impacts will act to accelerate the destabilization of populations and governments. Climate-driven crises are already happening there. Lack of water and changing agricultural patterns are at the root of crises in Darfur and Somalia, present day examples of failed social structures and governments, leading to widespread humanitarian crises and extremism.

In South and Central America – melting glaciers in Venezuela and the Peruvian Andes will directly impact water supplies and hydroelectric power. The Peruvian plains, northeast Brazil and Mexico will experience longer and more serious droughts. Land degradation and loss of food production will hit hard in Latin America – particularly Brazil whose economy is fueled by food exports – possibly leading to social disruptions and significant migration. We need only reflect on present immigration and security challenges along the U.S. southern border to get a glimpse of what the future could hold: immigration driven not by a search for a better economic life but in search of basic needs.

In Bangladesh, the growing threat of more frequent and intense typhoons in the Bay of Bengal has the potential for wiping out essential coastal agriculture and fishing areas, just as it did in 1991 resulting in Operation Sea Angel. Greater and more prolonged coastal typhoon damage would create an unprecedented humanitarian crisis, which could drive literally millions of refugees northwest toward India in search of relief.

As the Himalayan glaciers recede, Asian nations like China, India and Pakistan will have to deal with internal and external unrest due to a much less reliable source of water from four great rivers – creating floods at some times of the year, prolonged drought during others – to meet the needs of growing populations. 40 percent of Asia's four billion people live within 45 miles of the coast – a coast that could be inundated by rising seas. Even the most modest projections of increased temperature and sea level rise include flooding and loss of significant percentages of coastal delta farmland and closely settled areas.

In the Middle East, the vast majority of highly diverse populations already depend on water sources external to their borders. A greatly increasing competition for diminishing supplies of water for agriculture and basic human needs will significantly ratchet up tensions in this historically critical region.

These potential climate change effects will not just create crisis events happening far away from American soil or along our borders. Disasters like Hurricane Katrina in 2005 reveal, in a very stark way, how a natural disaster-caused humanitarian crisis can quickly lead to suffering, civil unrest and the need for a massive, expensive and sustained mobilization of resources.

As CNA Military Advisory Board member Vice Admiral Richard Truly said it is not like "some hot spot we're trying to handle." "It's going to happen to every country and every person in the whole world at the same time."

And while the effects of global warming create this environmental havoc, its principal dynamic will be to shift the world's balance of power and money.

Drought and scant water have already fueled civil conflicts in global hot spots like Afghanistan, Nepal and Sudan, according to several new studies. The evidence is fairly clear that sharp downward deviations from normal rainfall in fragile societies elevate the risk of major conflict.

Climate impacts like extreme drought, flooding, storms, temperatures, sea level rise, ocean acidification, and wildfires – occurring more frequently and more intensely across the globe – will inevitably create political instability where societal demands for the essentials of life exceed the capacity of governments to cope. As noted above, fragile governments will become failed states, and desperation and hopelessness will drive whole populations to be displaced on a scale far beyond what we see today. And this turmoil and power vacuum creates a more fertile breeding ground for extremists and the terrorism that can follow.

The U.S. Military will be called to respond to these new threats -- mobilizing to meet the needs of humanitarian crises, like our response to the 2004 tsunami in Indonesia. At the same time, we will be confronted with more frequent resource based conflicts in the most volatile regions of the world. Climate-driven disruption is such a viable threat that the Pentagon has already started to prepare contingencies for such scenarios, and will focus on the issue in its 2010 Quadrennial Defense Review, as will the State Department in its Quadrennial Diplomacy and Development Review.

At the same time – and this is at the nexus of climate change, energy and national security – increasing demand for, and dwindling supplies of fossil fuels will add greatly to this instability, in many of the very same places worst hit by climate change.

In our second report, *Powering America's Defense: Energy and the Risks to National Security*, the CNA Military Advisory Board concluded that America's current energy posture constitutes a serious and urgent threat to national security – militarily, diplomatically and economically.

Militarily, our dependence on oil stretches our military thin because we are obliged to protect and ensure the free flow of oil in hostile or destabilized regions – even as our troops are on their third and fourth deployment in Iraq and Afghanistan. Protecting our oil dependence jeopardizes our military and exacts huge price tag in dollars and lives.

Beyond assuring the free flow of oil, our nation's, and our military's inefficient use of fuel adds to the already great risks assumed by our troops. It reduces combat effectiveness and puts our troops – more directly and more often – in harm's way.

Fuel convoys can stretch over great distances, traversing hotly contested territory and become attractive targets for enemy forces. Ensuring convoy safety and fuel delivery requires a tremendous diversion of combat force. As in-theater energy demand increases, more assets must be diverted to protect fuel convoys rather than to directly engage enemy combatants.

We saw this in Iraq and we are certainly seeing it again in Afghanistan where the tempo of military operations, the size of the force and its effectiveness is literally paced by our ability to get fuel when and where it's needed.

Outside the theater of combat, our country's dependence on oil undermines our foreign policy goals and US leverage because it entangles us with hostile regimes. The United States sent $386 billion dollars overseas in 2008 to pay for oil; much of this money went to countries that are hostile to our interests.

This dependence cripples our foreign policy and weakens our leverage internationally and limits our options. Much too frequently we find ourselves entangled with unfriendly rulers and undemocratic nations, simply because we need their oil.

But unlike what many believe – it is not just foreign oil that jeopardizes our energy security. It is **all oil**. We simply do not have enough sustainable oil resources in this country to free us from the stranglehold of those who do. The Military Advisory Board concluded our dependence on **all oil** is a national security threat in part because the United States controls only 3 percent of the world's known oil reserves but uses over 25 percent of the world's oil supplies – we will never have enough domestic supply to meet our need for this fuel so we must deliberately and effectively wean ourselves from it.

And, our report concluded that it is not just all oil, but all fossil fuels that pose an unacceptable level of risk to our nation exploitable by those who wish to do us harm.

We identified a series of converging risks posed by our fossil fuel dependence.

Economically – it undermines our stability. As I noted earlier, our approach to energy is a key part of our current financial crisis. We are heavily dependent on a global petroleum market that is highly volatile. In the last year alone, the per-barrel price of oil climbed as high as $140, and dropped as low as $40. But this price volatility is not limited to oil – natural gas and coal prices also had huge spikes in the last year. The benchmark Central Appalachian coal price hit $175 per short ton. While economic downturn has caused those prices to come down, they still remain high and will continue to climb again once the economy recovers. While these resources may be plentiful, they are increasingly difficult to access, and have associated local environmental impacts, such as slurry spills and smog. The economic and environmental costs are steep.

There are many who say we cannot afford to deal with our energy issues right now. But if we don't address our long-term energy profile in significant ways, beginning now – future economic crises will dwarf this one. The price shocks of 1973-74, the late 1970s/early 1980s, and early 1990's were all followed by recessions. If oil prices rose to $200 per barrel, the U.S. would spend $1.5 trillion per year on oil, which would be equal to 22% of take-home pay (for all Americans who pay taxes). In other words, the U.S. will be broke long before oil prices hit $200 per barrel, and the rest of the world would be sure to follow.

The bottom-line is we can invest now in changing our energy posture or pay much more later, with far fewer options available. The current economic recession will end, U.S. energy demands will increase, and the volatile cycle of fuel prices will become sharper and shorter because the market for fossil fuels will be shaped by finite supplies and increasing demand. Continuing the United States' pattern of energy usage in a business-as-usual manner creates an unacceptably high threat level.

Unless we take steps now, not later, to prevent, mitigate and adapt to these challenges, the conflict over finite resources – from food to fuel – caused by rising energy demand and accelerating climate change will lead to a significant increase in conflicts, and in conflict intensity.

We need to carefully avoid the temptation to ignore these connections, and take only small steps to address narrow issues. Large, interconnected security challenges require bold, comprehensive solutions.

"We face," as the late John Gardner once said "a series of opportunities brilliantly disguised as unsolvable problems."

Members of the Committee, we must recognize we are at a pivotal moment in history, facing a Gordian knot unlike any the world has seen before. Those who say that now is not the time to act fail to recognize the gravity and urgency of our energy and climate change challenges – but they also fail to understand the **opportunity**.

There is a new multibillion-dollar revolution underway in clean technology around the world. And there is compelling evidence that clean energy policies are powerful economic drivers. Precedent setting statewide efficiency standards saved Californians $56 billion – the equivalent of $1000 per household – which were spent on goods and services, and created 1.5 million additional jobs. Energy efficiency – is the cleanest fuel that need never be mined, drilled or burned – and it represents a barely tapped resource that holds enormous power for all economies of the world.

The same is true for a whole host of clean and sustainable energy sources. There is general agreement that there is no "silver bullet" to meet our growing energy needs, however, there are a lot of "silver buckshot" that can be used to create a viable portfolio of future energy sources, not reliant on green house gas producing feed stocks and technologies. The United States can seize this opportunity to bring our great innovation, technology infrastructure and private capital to the forefront with the right kind of visionary legislation and policies.

Perhaps most important is the opportunity these challenges create for us to demonstrate, once again, the core values of America leadership to the world. How can we expect our enemies, or even our friends and allies, to understand the value of freedom and democracy if we are not actively engaged in protecting the essential water and soil required for its seeds? Ensuring that fragile democracies have the technologies needed to prevent, mitigate and adapt to climate change and for cleaner energy self reliance will help grow our economy and protect theirs. Most importantly, America's leadership and key partnership in addressing these truly global challenges will act as a powerful catalyst for international collaboration to better address a whole host of pressing issues. The United States has an opportunity and obligation to lead. We can untie the

Gordian knot of energy, climate and national security – and lead to much greater global security.

Members of the Committee, if we act with boldness and vision now, future generations will look back on this as a time when we rose above narrow interests and partisan divides to address the most pressing issues of our time. Through thoughtful dialogue, effective leadership and united action, we can transform daunting challenge into sustained security and prosperity across the planet, creating a better quality of life for our nation and for our world.

RESPONSES FROM VICE ADMIRAL DENNIS MCGINN TO QUESTIONS FROM MEMBERS OF THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE

October 30, 2009

Questions from Senator Amy Klobuchar

Q 1. The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

A: In Africa, projected rising temperatures will dramatically reduce water availability, soil moisture, arable land and food production. Combined with increased extreme weather events – climate impacts will act to accelerate the destabilization of populations and governments. Climate-driven crises are already happening there. Lack of water and changing agricultural patterns are at the root of crises in Darfur and Somalia, present day examples of failed social structures and governments, leading to widespread humanitarian crises and extremism.

In South and Central America – melting glaciers in Venezuela and the Peruvian Andes will directly impact water supplies and hydroelectric power. The Peruvian plains, northeast Brazil and Mexico will experience longer and more serious droughts. Land degradation and loss of food production will hit hard in Latin America – particularly Brazil whose economy is fueled by food exports – possibly leading to social disruptions and significant migration. We need only reflect on present immigration and security challenges along the U.S. southern border to get a glimpse of what the future could hold: immigration driven not by a search for a better economic life but in search of basic needs.

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As the Himalayan glaciers recede, Asian nations like China, India and Pakistan will have to deal with internal and external unrest due to a much less reliable source of water from four great rivers – creating floods at some times of the year, prolonged drought during others – to meet the needs of growing populations. 40 percent of Asia's four billion people live within 45 miles of the coast – a coast that could be inundated by rising seas. Even the most modest projections of increased temperature and sea level rise include flooding and loss of significant percentages of coastal delta farmland and closely settled areas.

In the Middle East, the vast majority of highly diverse populations already depend on water sources external to their borders. A greatly increasing competition for diminishing supplies of water for agriculture and basic human needs will significantly ratchet up tensions in this historically critical region.

Q 2. In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions of the world. In South Asia, India's rivers are vital to sustaining agriculture and
Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The
United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position to deal with or prevent this type of instability?

A: Unless we take steps now, not later, to prevent, mitigate and adapt to these challenges, the conflict over finite resources – from food to fuel – caused by rising energy demand and accelerating climate change will lead to a significant increase in conflicts, and in conflict intensity. Putting a price on carbon will help create the right responses throughout government and the private sector to meet the challenges.

"We face," as the late John Gardner once said "a series of opportunities brilliantly disguised as unsolvable problems."

We must recognize we are at a pivotal moment in history, facing a Gordian knot unlike any the world has seen before. Those who say that now is not the time to act fail to recognize the gravity and urgency of our energy and climate change challenges – but they also fail to understand the **opportunity**.

Perhaps most important is the opportunity these challenges create for us to demonstrate, once again, the core values of America leadership to the world. How can we expect our enemies, or even our friends and allies, to understand the value of freedom and democracy if we are not actively engaged in protecting the essential water and soil required for its seeds? Ensuring that fragile democracies have the technologies needed to prevent, mitigate and adapt to climate change and for cleaner energy self-reliance will help grow our economy and protect theirs. Most importantly, America's leadership and key partnership in addressing these truly global challenges will act as a powerful catalyst for international collaboration to better address a whole host of pressing issues. The United States has an opportunity and obligation to lead. We can cut the Gordian knot of energy, climate and national security – and lead to much greater global security. With the right kind of visionary mandates and policies, this can happen.

RESPONSES FROM VICE ADMIRAL DENNIS MCGINN TO QUESTIONS FROM MEMBERS OF THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE
October 30, 2009

Senator Lamar Alexander

Q 1. Do you believe our failure to take the lead in nuclear technology while other countries forge ahead creates any potential security threat? For instance, the Russians are currently building a nuclear reactor for President Hugo Chavez of Venezuela. Would it be better if the U.S. were building that reactor instead of the Russians? Does the Russians' more enthusiastic embrace of nuclear technology give them an advantage in forging alliances around the world?

A: The United States is ceding the competitive edge on a whole host of low carbon, renewable, clean technologies, including nuclear power. It is imperative that the Congress put a price on carbon to create the market certainty for low carbon technologies, but Congress should not cherry pick those technologies. If the cost of carbon, which currently exists but simply is not calculated, becomes a market reality, powerful American forces of ingenuity and innovation will be unleashed to find the smartest least expensive low carbon solutions.

Q 2. Which is more of a threat to the national security of the United.States: a. American reliance on Chinese, Indian, and Russian technology for nuclear power, scientific innovation and manufacturing capabilities as we would surely see under Waxman-Markey - orb.
0.2 degree increase in the average temperature of the globe? (0.2 degrees Celsius is the climate benefit we'll see if the u.s. institutes cap and trade, but other countries do not)

A: My colleagues and I did not explore this type of comparison in our evaluation of the threats to national security posed by climate change. However, we need to recognize that there is a new multibillion-dollar revolution underway in clean technology around the world. With the right kind of legislative mandate and ensuing national policies, America's innovation and enormous private sector can put us in a great economic and security position. In particular, there is compelling evidence that clean energy policies are powerful economic drivers Energy efficiency - is the cleanest fuel that need never be mined, drilled or burned - and it represents a barely tapped resource that holds enormous power for all economies of the world.

The same is true for a whole host of clean and sustainable energy sources. There is general agreement that there is no "silver bullet" to meet our growing energy needs, however, there are a lot of "silver buckshot" that can be used to create a viable portfolio of future energy sources, not reliant on green house gas producing feed stocks and technologies. The United States can seize this opportunity to bring our great innovation, technology infrastructure and private capital to the forefront with the right kind of visionary legislation and policies.

3. You said in your testimony that for this to work "It will take all international participation" -It sounds as if we won't get that from China and India.

a. What happens when the U.S. goes it alone and essentially weakens our own economy, manufacturing base, innovation capability, and currency to the ultimate benefit of China and India?

b. Where does the U.S. stand with regard to international competiveness and our national security?

A: CNA's Military Advisory Board reports do not directly address these questions, however, in order to be effective, America's leadership in the world community must be on the basis of both example and partnership. If we do not step forward, in both word and deed, we cede a critical position of moral authority and diplomatic leverage to address the truly global challenges of climate change and energy insecurity. We cannot allow other nations' reluctance to act be an excuse for no action on our own part, nor can we allow them to say that coordinated action is impossible due to a lack of U.S. leadership.

Senator BOXER. Thank you very much.

And now we turn to a minority witness who is here, and we welcome you, Major General Robert H. Scales, retired.

STATEMENT OF MAJOR GENERAL ROBERT H. SCALES, U.S. ARMY (RETIRED)

Mr. SCALES. Thank you very much, Madam Chairperson. It is indeed an honor to address this hearing on the national security implications of the Clean Energy Jobs and American Power Act.

Our intellectual and popular culture thrives on speculating about the horrific effects of mega-disasters. But the historical record strongly suggests that such devastating disasters rarely if ever result in large scale wars. In fact, more often than not, sadly, wars cause pandemics, starvation and societal dislocation rather than result from them.

If the more popular climate change models are right, perhaps some time in the very distant future glacial fed rivers might dry up, sea levels might rise and areas of the planet might become more waterless. Some environmental scientists conclude that such a climatic crisis would precipitate human friction in the form of mass migration away from ocean fronts, river valleys and regions of the world that suffer from drought.

The problem is that even if such disasters occur, they will not likely be a cause for serious wars, particularly a war between a major competitor and the United States. In fact, a brief turn through the historical record suggests that periods of great societal stress causing enormous suffering and dislocation reduce the likelihood of state versus state conflict.

Mass misery caused by climatic and environmental disasters occurs so slowly that populations adjust through migration and societal atrophy. Such phenomena create social miasma that inhibits rather than fuels aggression. In a word, states about to collapse from the consequences of natural disasters are more concerned with survival than picking a fight with a global competitor.

Wars that affect major nation-states will be precipitated in the future by the same factors that have ignited conflict for millennia. A far greater strategic threat, at least in the shorter term defined by the next 20 years, will come from a dramatically reduced access to raw and refined fossil fuels that likely be an unintended consequence of this bill.

This argument rests on two premises. First, that fossil fuels will continue to power our war making capability for generations. And second, that this bill may reduce our ability to surge fossil fuel production should we face the threat of a large scale major war in the future.

There is no scientific evidence that suggests that wars will be propelled and sustained by any power source other than fossil fuels in the future. Dominance in machine warfare on the land, sea and in the air requires fuels that generate the greatest combustion and heat from the smallest volume. Only fuels derived from petroleum will be capable of propelling aircraft, most ships and ground vehicles on and over battlefields where performance is measured by how efficiently fuels can be transferred into energy.

Industrial age machines must still be produced in large numbers to win against a large scale competitor. Ships, vehicles, guns and aircraft will continue to be made predominantly from steel, aluminum, rubber and titanium. And all of these machines and the material to support them must be transported to the theater of war and across and over the battlefield with fossil fueled engines.

This bill might well over the decades slowly diminish the ability to produce fossil fuels in the strategic confines of American territory. According to one study, refining capacity could plummet because the cost of doing business would soar. Production at U.S. refineries would drop while production in countries that do not limit greenhouse emissions would rise.

We have no assurance that off shore refining would take place in regions secure from foreign power influence. According to several studies, the United States would have to increase its petroleum imports by one-fifth by 2030 as our domestic production would plummet by as much as 25 percent. Should we suffer such consequences, the ability of the United States to surge its wartime energy production might well be held hostage to foreign influence.

This bill would reduce American industrial capacity as the very industries essential for the production of war fighting material would move overseas. Recent studies suggest that this bill would result in a loss of industrial production of over 6 percent by 2030 and a consequent loss of over half a million manufacturing jobs, many of those in the defense industry.

Nothing in this bill will reduce the likelihood of American involvement in future wars, nor will it improve America's war making capabilities. Indeed, over the decades, the consequences of this bill might well reduce American influence and retard our ability to deter and fight wars in the future.

Thank you.

[The prepared statement of Mr. Scales follows:]

Statement by

MG (Ret) Robert H Scales

Before the

Senate Committee on the Environment and Public Works

October 28th, 2009

Hearings on Climate Change and National Security

I am honored to address this hearing on the implications of the Clean Energy Jobs and American Power Act on American security. For the record I would like to begin with two important stipulations. First, I am a historian and a military futurist, not an environmental expert. I have deep reservation concerning the science behind the warnings about global climate change contained in this bill but I will not argue them here. Instead I will attempt to contrast the security risk inherent in a possible long term rise in earth's temperature with the shorter term risks inherent in a potential loss of fossil fuel production and economic slowdown that will likely be the consequence of this bill. Second, I have no relationship whatsoever with the energy industry or any corporation or think tank that advocates for these industries. I am not being paid for my testimony by anyone.

Our intellectual and popular culture thrives on speculating about the horrific effects of mega disasters. All too often we read about how global conflagrations will emerge as a consequence of world hunger, pandemics, a population explosion, water shortage, asteroid strikes and, lately of course, global warming. To be sure such unlikely events would cause enormous suffering and societal dislocation. But the historical record strongly suggests that such devastating humanitarian disasters rarely if ever result in large scale wars. In fact more often wars cause pandemics, starvation and societal dislocation rather than result from them.

If the more popular climate change models are right (and I'm not sure they are) perhaps some time in the very distant future, perhaps several generations from now glacial fed rivers might dry up, sea levels might rise and arid areas of the planet might become more waterless. Some environmental scientist conclude that such a climatic crises will precipitate human friction in the form of mass migrations away from ocean fronts, river valleys and regions of the world suffering from draught. This argument has been accepted by some military theoreticians. The problem is that even if such disasters occur they will not likely be a serious cause for war, particularly a war between a major peer competitor and the United States. In fact a brief turn through the historical record suggest that periods of great societal stress causing enormous suffering and dislocation reduces the likelihood of state versus state conflict. Mass misery caused by climatic and environmental disasters occur so slowly that populations adjust through migration and social atrophy. Such phenomena create social miasma that inhibits rather than fuels aggression. In a word states about to collapse from the consequences of natural disasters are more concerned with survival than picking a fight with a global competitor.

Wars that affect major nation states will be precipitated in the future by the same prosaic and predictable factors that have ignited human conflict for millennia: miscalculations by egomaniacal leaders, the coveting of territory, contests over strategic resources such as oil, simple greed, religious or ideological fanaticism as well as many other forms of political, social and tribal friction. A far greater strategic threat, at least in the shorter term defined by the next twenty years, will come from a dramatically reduced access to raw and refined fossil fuels that will likely be an unintended consequence of this bill. This argument rests on two premises: first, that fossil fuels will continue to power our war making capability for generations; and, second, that this bill may reduce our ability to "surge" fossil fuel production should we face the threat of large scale war in the future.

There is no scientific evidence that suggests that wars will be propelled and sustained by any power source other than fossil fuels. During the late nineties I created and superintended the "Army After Next" series of strategic wargames. These games are still being conducted as the "Unified Quest" strategic games at the Army War College. In virtually every game we asked scientists from think tanks, the government and academia to offer evidence that fossil fuels will be replaced by other sources of power such as hydrogen, nuclear and electricity. During these and many subsequent games and studies, in spite of assiduous efforts to postulate alternatives, so far none have been found. The reasons are simple, consistent and unambiguous: we win wars by producing fighting machines more capable than the enemy's. Dominance in machine warfare on the land, sea and in the air requires fuels that generate the greatest combustion and heat from the smallest volume. Only fuels derived from petroleum will be capable of propelling aircraft, most ships and ground vehicles on and over battlefields where performance is measured by how efficiently fuels can be transferred into energy.

Big wars will require that the nation "surge" its war-making capability in a very short time. To be sure the United States will gain substantial advantage on future battlefields by exploiting its superior information technology. Such an advantage will be sustained with a relatively low fuel cost. But industrial age machines must still be produced in large numbers to win against a large scale competitor. Ships, vehicles, guns and aircraft will continue to be made predominately from steel, aluminum, rubber and titanium. Ammunition and missiles will continue to require nitrates for explosives. An all of these machines and the materiel to support them must be transported to the theater of war and across and over the battlefield with fossil fueled engines.

Since the beginning of the twentieth century the single most critical resource for the national security health of major powers has been petroleum. After the Royal Navy converted from coal to steam propulsion during the inter war years access to oil in the Middle East through the Suez Canal became a corner stone of British defense and diplomatic policies. Perhaps the single most compelling motive for Japan's surprise attack on Pearl Harbor was the need to gain access to the oil rich Dutch East Indies. After months of failure the American strategic bombing campaign against Nazi Germany hit pay dirt when the central target shifted from industrial to oil production in late 1944. It goes without saying that much of American foreign policy and much of our war-making efforts have been devoted to protecting our access to overseas oil resources.

If the forecasts are correct this bill will, over the decades, slowly diminish the ability to produce fossil fuels in the strategic confines of American territory. According to one study American refining capacity could plummet because the cost of doing business would soar. Production at U S refineries would drop while production in counties that do not limit green house emissions would rise. We will have no assurance that off shore refining would take place in regions secure from foreign power influence. According to this study the United States would have to increase its petroleum imports by one fifth by 2030 as our domestic production would plummet by as much as 25%. Should we suffer such consequences the ability of the United States to surge its wartime energy production might well be held hostage to foreign interference and, sadly, our young men and women might well find themselves permanently stationed in areas of great danger and volatility in order to secure American access to foreign oil.

In a democracy the military power of the state rests ultimately on its economic health and resiliency. This bill would in fact reduce American industrial capacity as the very industrial age industries essential for the production of warfighting materiel move overseas to avoid the punishing consequences of this bill. According to recent studies this bill would result in a loss of industrial production of over 6% by 2030 and a consequent loss of over half a million manufacturing jobs. These are the very workers who we would rely on to produce the materiel needed to win a future war against a major competitor.

Advocates of this bill believe passionately that it will reduce America's production of greenhouse gasses. Some suggest that it will create jobs. They may or may not be correct. But nothing in this bill will either reduce the likelihood of American involvement in future wars nor will it improve America's war making capabilities. Indeed over the decades the consequences of the bill might well reduce American influence and retard our ability to deter and fight wars in the future.

Secure access to sources of oil has been a major goal of every major nation's war making strategy since the invention of the internal combustion engine. The Japanese started a war to secure access to it, Nazi Germany lost a war because of it and, without increasing American domestic production, our armed services might well be engaged in shooting wars over access to it for many generations. Reducing green house gasses is an important national goal. But we should never risk the lives of our men and women in uniform nor increase our vulnerability a future enemy to achieve it.

Environment and Public Works Committee Hearing
October 28, 2009
Follow-Up Questions for Written Submission
Questions for Scales

Questions from:
Senator Amy Klobuchar

1. The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

Answer:
Environmental changes have yet to affect stability in any region of he world and probably will not over the next few decades. Instability rarely if ever results from environmental changes because these changes occur so slowly that populations adjust and governments adapt. Political destabilization occurs principally due to traditional reasons: greed, a contest for resources, territorial ambitions, as well as ideology and religious zeal. Therefore military deployment that respond to environmental changes will be for humanitarian not military motives.

2. In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions of the world. In South Asia, India's rivers are vital to sustaining agriculture and Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position
to deal with or prevent this type of instability?

Answer:
The bill does nothing to decrease tensions because tensions do not result from climate changes. Pakistan and India are tense because of Cashmere and a half century of wars between the two countries.

Senator Lamar Alexander

1. Do you believe our failure to take the lead in nuclear technology while other countries forge ahead creates any potential security threat? For instance, the Russians are currently building a nuclear reactor for President Hugo Chavez of Venezuela. Would it be better if the U.S. were building that reactor instead of the Russians? Does the Russians' more enthusiastic embrace of nuclear technology give them an advantage in forging alliances around the world?

Answer:
I believe that the United States has fallen behind in the development and deployment of nuclear power because of environmental disinformation and politics. The Navy has been operating nuclear powered ships for over half a century. Yet virtually every attempt to build a nuclear power facility in the United States has been rejected by communities that have been unduly influenced by false information about the dangers of nuclear power. We simply must overcome the political barriers against nuclear power and construct nuclear power plants as fast as possible.

2. Which is more of a threat to the national security of the United States:
a. American reliance on Chinese, Indian, and Russian technology for nuclear power, scientific innovation and manufacturing capabilities as we would surely see under Waxman-Markey - or -
b. 0.2 degree increase in the average temperature of the globe? (0.2 degrees Celsius is the climate benefit we'll see if the U.S. institutes cap and trade, but other countries do not)

No question that American reliance on foreign nuclear technology is the greater national security threat.

Senator BOXER. Thank you very much.

And now we go to a majority witness, and I am just going to take a minute to let everybody know who Drew Sloan is.

Drew Sloan is pursuing a joint MBA and MPA from Harvard Business School and Harvard Kennedy School. He spent 5 years in the U.S. Army where he served in Afghanistan and Iraq. He was awarded two Bronze Stars and a Purple Heart. He graduated from the United States Military Academy at West Point in 2002. And we are just so honored to welcome you here today. Thank you.

STATEMENT OF ANDREW SLOAN, CAPTAIN, U.S. ARMY (RETIRED); FELLOW, TRUMAN NATIONAL SECURITY PROJECT

Mr. SLOAN. Thank you.

Madam Chairwoman, Ranking Member Inhofe, members of the committee, ladies and gentlemen, it is my honor to be here with you today to discuss this very important issue of climate change and national security.

I give the following testimony under the assumption that the world's climate is changing, and the burning of fossil fuels and increased deforestation are the main drivers of that change. Furthermore, in the coming years, this change will lead to more severe and frequent precipitation events and prolonged periods of drought for many areas. These are environmental changes, but they will have human impacts, both here and abroad.

The effects of climate change are the ambushers on the horizon. Our great military cannot take a hill that will stop temperatures from rising, or wage a counterinsurgency against a storm surge. An exquisitely coordinated bombing campaign cannot stop glaciers from melting nor can all the ships in our Navy prevent sea levels from rising. However, while the military cannot stop climate change, it will be the institution that will be forced to deal with it.

As a former infantry officer with combat experience, I believe I have an appreciation for what I think our forces will face if we do not act decisively against climate change. Please allow me to present a potential climate change induced security threat.

In Bangladesh, 10 percent of the country's 155 million citizens live just 2 to 3 feet above sea level. Storm surges, magnified by rising sea levels, could very conceivably create a quasi-permanent state of flooding. This flooding of sea water would damage water sources and ruin crops. Water and food become increasingly scarce, and sanitation levels begin to plummet, opening the door for diseases such as malaria and cholera.

People, potentially millions of people, will be forced to relocate but have no good options as to where to go. India, by this time, will have completed the wall that they are already building to keep the Bangladeshis out, so they will not be able to go there. The central government in Dhaka will potentially be overwhelmed by these events.

With nowhere for people to go, refugee camps will be created, and a case for a humanitarian mission will be made. As if often the case, anger, bitterness and hopelessness will spread throughout these camps, and like the mosquitoes born in the stagnant water left after the floods, extremism will be born and spread as well.

In a relatively short span, climate change has turned the already poor nation of Bangladesh into a failed state, potentially destabilized an entire region, sparked a humanitarian crisis, and created a breeding ground for extremists. All of these conditions will necessitate a response from our national security apparatus.

This conceivable situation is what I think of when I picture what General Anthony Zinni, former CENTCOM Commander, was referring to when he acknowledged that failing to reach our greenhouse gas emissions will force us to pay a price in military terms that will involve human lives and exact a human toll. This is the human face of climate change, and this is the national security threat.

While the situation I described above is hypothetical, the threat and demands it would place on our military are not that abstract. In fact, in 2004, when a tsunami devastated large portions of Indonesia, it was the American military that responded. In 1992, America sent its military into Somalia to feed those forced into starvation by prolonged periods of drought. A military response is required largely because the military was, and remains, the only institution capable of such a response.

While these actions of benevolence and generosity arguably depicted America at its best, they were not without cost. Operations in Indonesia cost an average of $5 million a day. When relief turned into peacekeeping in Somalia, 16 Army Rangers lost their lives.

As a changing climate increases the severity of droughts in Africa and the intensity of storms in Asia, the demand for an American response will increase as well. Not only will this be costly in dollar and human terms, but it will also likely impede the military's ability to adequately address the more conventional threats that are sure to arise. As climate change wreaks havoc across the world, so, too, will it wreak havoc on the military's ability to properly handle the Nation's national security interests.

I stand here before you today as a former infantryman, as a graduate of West Point, as an educated citizen to unequivocally urge this body to chart a new path away from the climate change ambush, to pass legislation that meets the threat of climate change head on by stimulating our economy and our people through the creation of a clean, new energy system for America.

America can and must do better. The security of our Nation depends upon it.

Thank you, and I have also submitted a written statement.

[The prepared statement of Mr. Sloan follows:]

WRITTEN STATEMENT OF ANDREW SLOAN, RETIRED US ARMY CAPTAIN FELLOW, TRUMAN NATIONAL SECURITY PROJECT

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS ON CLIMATE CHANGE AND NATIONAL SECURITY

OCTOBER 28, 2009

Chairman Boxer, Ranking Member Inhofe, Members of the Committee, Ladies and Gentlemen, I am honored to appear here today with this distinguished panel to discuss the incredibly important issue of climate change and national security. I am currently a dual-degree graduate student at Harvard Business School and the Harvard Kennedy School of Government. More importantly for these hearings, however, I am also a former Captain in the US Army with tours in both Iraq and Afghanistan. Additionally, I have worked with Amory Lovins at Rocky Mountain Institute as well as spent time at the National Renewable Energy Laboratory. It is through this combination that I feel qualified to speak to the challenges that our nation's national security apparatus will face as the impacts of climate change become more pronounced.

I give the following testimony under the assumption that the world's climate is changing and that the burning of fossils fuels and increased deforestation since the beginning of the Industrial Revolution has artificially accelerated this change. Reports produced by the Intergovernmental Panel on Climate Change reveal that global atmospheric concentrations have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values.[1] In fact, the IPCC states that CO_2 levels have increased from 280 ppm to 379 ppm over that time with the fastest acceleration coming in the last 10 years. Additionally, continuous measurements taken from the observatory atop Mauna Loa, Hawaii depict a steady rise in atmospheric CO_2 levels since the measurements began in the 1950s.[2]

Again according to the IPCC, a steady rise in CO2 levels will likely to almost certainly result in severe changes to the world's climate. The effects of this change are deemed very likely to result in a rise of average world temperatures and increased precipitation events in terms of severity and frequency. The IPCC further stipulates that climate change will likely result in more areas being affected by drought conditions, increases in intense tropical cyclone activity, and a greater incidence of extreme high sea levels.[3] These are environmental changes, but they will have human impacts- both here and abroad.

I am not and never have been a scientist. But I have been a soldier in combat and like all soldiers in combat, I've had to make decisions with less than perfect information and various levels of uncertainty. As former Army Chief of Staff, General Gordon Sullivan wrote in a study on national security and climate change, "if you wait until you have 100% certainty, something bad is going to happen to you on the battlefield." The reality in combat is that absolute certainty is a very rare commodity. However, if 99 out of 100 different sources came to me and said that if I kept leading my soldiers down a certain path then we'd almost certainly get sniped at, very likely to be targeted by a roadside bomb, and likely to get ambushed from all sides, then I'd change my plan. I'd rather find another way to accomplish my mission than listen to a lone outlier simply because his advice allows me to continue down the road I'm already on.

That is what I would have done in Afghanistan and it's what America must do now. Though experts and scientists have been warning us for years that we are walking into an ambush, we have ignored this advice and chosen instead to listen to the relative few who tell us that there really is no ambush or that if there is one, it won't be that bad. I've been ambushed- my face will always bear the scars from that day— and I can tell you that from the receiving end, all ambushes are bad. The time has come for America to stop hiding from the danger of climate change and instead lead the world in the fight against it.

Our nation's military, as great as it is, cannot take a hill that will stop temperatures from rising or wage a counterinsurgency against a storm surge. An exquisitely coordinated bombing campaign cannot stop glaciers from melting nor can all the ships in our Navy prevent sea levels from rising. If the world is to stop these things from happening then the fight must start here. It must start here in the halls of Congress and emanate throughout the government and private sector in the form of the creation of a vibrant, clean economy that revitalizes, not suppresses this great nation and those who live within it.

If Congress and America fail to lead on this issue then there will be a role for the military to play. More violent storms will wreck havoc both on our cities and our many military bases that are located along the coasts and will require a response from our military. We saw this during the aftermath of Katrina when, amidst two wars, a brigade from the 82nd Airborne Division was sent from North Carolina to New Orleans to assist in the stabilization effort. Melting in the Arctic has opened sea-lanes that have never been open before requiring a naval response as well as increasing tensions over the potential resources located in what was a previously inaccessible area. These are military realities caused by climate change.

In regards to America's internal coastal protection or defending of the new Arctic sea passages, I am not and never claimed to have been a reconstruction engineer or a naval officer. I was an Infantry officer. I lead soldiers on the ground in hostile situations and my experiences there have given me an appreciation for what our fighting men and women will face in the future if we do not act decisively against climate change.

Who among us would stand by and watch our loved ones slowly wither away and die from starvation? Who would not look to relocate if the area where you lived contained less and less drinking water, year after year? Or if the land you lived on was flooded so often that you and your family were almost permanently living in water, unable to find food and increasingly susceptible to diseases such as malaria, dengue fever, or cholera?

The answer is that we would all go elsewhere and that they—those living in areas that will be particularly hard hit by climate change such as sub-Saharan Africa or Southern and Southeast Asia—all will as well. The question that we must be asking is not just where will people go, but how are the people already living there going to react? This scenario could play out in a number of areas, but let me quickly describe how one such situation could develop and how it would impact our national security.

If sea levels continue to rise, low-lying communities become increasingly vulnerable to storm surges not to mention tsunamis like the one that devastated large swaths of Southeast Asia in 2004. This is a particularly salient fact for Bangladesh given that 46% of its population, or 71 million people, lives in low-lying areas.[4] 15 million of those live just 2-3 feet above sea level.[5] Unimpeded climate change looks like the following for the people of Bangladesh.

Storm surges magnified by rising sea levels create a quasi-permanent state of flooding. This flooding of seawater makes a vast majority of the water supply undrinkable and unusable for agriculture. Millions then find themselves existing in flooded land without adequate sources of clean, potable water or sufficient means to produce or procure food. Sanitation levels diminish and, combined with a lack of clean water, diseases such as cholera and malaria begin to wreck havoc. People—potentially millions of people—will be forced to relocate, but have no good options as to wear to go. India by this time will have completed the wall that they are already building to keep the Bangladeshis out, so they won't be able to go there. The central government in Dhaka will potentially be overwhelmed by these events.

With nowhere for people to go refugee camps will be created and a case for a humanitarian mission, likely involving the U.S. in some capacity, will be made. As is often the case, anger, bitterness, and hopelessness will spread through these camps and, like the mosquitoes born in the stagnant water left after the floods, extremism will be borne and spread as well. In a relatively short span, a change in the climate has turned the already relatively poor nation of Bangladesh into a failed state, potentially destabilized an entire region, sparked a humanitarian crisis, and created a breeding ground for extremists. All of these conditions will necessitate a response from our national security apparatus. This conceivable situation is what I think of when I picture what GEN Anthony Zinni, former CENTCOM Commander, was referring to when he acknowledged that failing to reduce our greenhouse gas emissions will force us to pay a price in military terms that will involve human lives and exact a human toll.[6] This is the human face of climate change. This is the national security threat.

While the potential situation I described above is hypothetical, the threat and demands it would place on the US military are not that abstract. In 2004, when a tsunami devastated large portions of Indonesia, it was the American military that responded. A military response was required largely because the military was, and remains, the only institution in the world capable of combining the security and logistical capabilities necessary for such an operation. In 1992, America sent its military into Somalia to feed those forced into starvation by prolonged periods of drought.

While these actions of benevolence and generosity arguably depicted America at its best, they were not without cost. Operations in Indonesia cost an average of $5 million dollars a day.[7] When relief turned into peacekeeping in Somalia, 16 US Army Rangers lost their lives. As a changing climate increases the severity of droughts in Africa and the intensity of storms in Asia, the demand for an American response will increase as well. Not only will this be costly in dollar and human terms, but it will also likely impede the military's ability to adequately address the more conventional threats that are sure to arise. As climate change wrecks havoc across the world so too will it wreck havoc on the military's ability to properly handle the nation's national security interests.

I stand before you today as a former Infantryman, as a graduate of West Point, and as an educated citizen to unequivocally urge this body to chart a new path away from the climate change ambush that our current course is leading us towards. To pass legislation that meets the threat of climate change head on by taking the appropriate and responsible measures to stimulate our economy and our people through the creation of a clean, new energy system for America. America can and must do better— the security of the nation depends on it.

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[1] IPCC Interim Working Group Report 1, April 2007, ; IPCC Synthesis Report, November 2007. (http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm)

[2] NOAA Climate Monitoring and Diagnostic Laboratory

[3] IPPC.

[4] Busby, Joshua "Climate Change and National Security: An Agenda for Action," Council on Foreign Relations (http://www.cfr.org/publication/14862/climate_change_and_national_security.html)

[5] CNA Report on "National Security and the Threat of Climate Change" (April 2007) (http://www.cna.org/nationalsecurity/climate/)

[6] Ibid.

[7] US State Department report on "Going the Distance: The U.S. Tsunami Relief Effort 2005" http://www.ciaonet.org/wps/dod147/dod147.pdf

Environment and Public Works Committee Hearing October 28, 2009
Follow-Up Questions for Written Submission

Answers by Drew Sloan

Questions from Senator Klobuchar:

The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

In its Global Trends 2025 Report, the National Intelligence Council found that Sub-Saharan Africa, the Middle East, and Central and Southeast Asia are most vulnerable to the purported effects of climate change such as increased drought, flooding, extreme weather, and hunger. A 2007 report issued by the Center for Naval Analysis (CNA) suggested that countries such as Kuwait, Kenya, and Somalia would be most affected by drought and water shortages while Southeast Asian countries such as Bangladesh and Sri Lanka are at great risk to sustain significant damages to their way of life from increased precipitation events.

A recent LA Times article highlighted the difficulties that Kenya—until recently a quite stable African nation—is having dealing with an ever-increasing number of both climate refugees from Somalia as well as internally displaced Kenyans who are abandoning their homes and traditional ways of life because changes in the weather are making it impossible for them to survive.

In my testimony, I referred to a potential situation in which climate change could significantly weaken the central government of Bangladesh. 15 million Bangladeshis live just 2-3 feet above seawater. Storm surges, magnified by rising sea levels, could potentially create quasi-permanent flooding that would taint water sources, ruin crops, and eventually force people to migrate away from the coastlines. As an already poor country, it is difficult to imagine that this migration would not place severe strain on the central government in Dhaka. Refugee camps would emerge and within them the potential for extremism to be borne and spread is quite high. In this scenario, laid out in greater detail in my testimony, the effects of climate change turn a small nation into a failed state, potentially destabilize an entire region, spark a humanitarian crisis, and create a breeding ground for extremists. Similar scenarios could play out in a number of states in Sub-Saharan Africa and Southern and Southeast Asia.

In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions ofthe world. In South Asia, India's rivers are vital to sustaining agriculture and Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position to deal with or prevent this type of instability?

In brief, it is puts another tool in our policy toolkit and allows us to prove to the world that America understands that climate change and its potential impacts are real and that we are taking steps to address it. In many ways, we're probably already past the point where we can completely stop or prevent the effects of climate change. However, by acting through the production of effective legislation, we will be able to stave off some, though probably not all, of the anger that will emerge out of the parts of the world where people are hit the hardest by climate change.

Senator BOXER. Thank you so much, Mr. Sloan.

Lieutenant Colonel James Jay Carafano. Is that correct? Carafano?

Mr. CARAFANO. Yes, Madam.

Senator BOXER. And you are a minority witness, and please proceed.

STATEMENT OF LIEUTENANT COLONEL JAMES JAY CARAFANO, U.S. ARMY (RETIRED); DEPUTY DIRECTOR, THE KATHRYN AND SHELBY CULLOM DAVIS INSTITUTE FOR INTERNATIONAL STUDIES; AND DIRECTOR, DOUGLAS AND SARAH ALLISON CENTER FOR FOREIGN POLICY STUDIES, THE HERITAGE FOUNDATION

Mr. CARAFANO. Thank you. I have just five points to make.

First, you know, I would like to say how constructive and productive I think this hearing is and how excited I am to look forward to it. What I have heard here today really makes me optimistic because I really believe that both sides share common goals. And I think that is the most important thing, that both sides, everyone interested in this debate, is interested in keeping this country safe, free and prosperous.

I also think that everyone shares a common goal that the United States would be a good steward of our global environment. So, I find that encouraging and productive and a good basis for moving forward.

The second reason why I think this hearing is amazingly important is because it does state in the Preamble of the Constitution that providing for the common defense is the fundamental obligation of Government, and I think it would be irresponsible to consider any major piece of legislation that is going to impact on such a vast swath of our economy and really drive our future and not think about and ponder the national security implications of what is being done.

That leads me to my third point, which is my perspective for answering your questions in the way I have. And it really combines some three things. The first is my 25 years of military service, a lot of which was spent dealing with strategy and policy issues. But I had a concomitant career that went along with that, much like General Scales, which is as a historian, and much of my historical work has been not just on military history but really looking at where the lines of military history and science and culture and public policy, economic and business, intersect, which I think is relevant particularly to this issue.

And the third is, as a professor who researches a lot of what is euphemistically called now wicked problems, which is complex public policy problems and deciding how do you find the right way to look at the right problem to get to the right answer.

And this leads me to my fourth point, and here is my concern. My concern is that making the case for any major piece of legislation based on a conclusion of its long-term impact on either the environment or energy production is incredibly problematic. I make that statement because in order to draw those kinds of conclusions you have to construct a complex system, and a system which in the end is so complex that I think it is incredibly unrealistic to think that you can actually draw anything other than merely subjective conclusions about how the future is going to unfold.

I just might illustrate that with an example. Many of you have probably heard of or read Jared Diamond's absolutely terrific book called Collapse, in which he does a terrific job talking about historically why societies, some societies, fade from the scene. Well, Diamond lists 12 variables alone that impact on how human environment interactions work out.

And he reaches those conclusions and analysis based on really drawing over a century of history and archeology. And he is looking backward with hindsight. He is not looking forward to where, and you see as the case studies unfold, human decisions and environmental change constantly change the nature of the problem every day.

So, what my argument is is arguing from a complex systems approach that we can predict how the environment, human decisions and conflict and violence and humanitarian needs will work out over the long term is simply incredibly unrealistic, and using that as an argument either for or against this bill I just think is incredibly inappropriate.

This leads to my fifth and last point, which is what my recommendation would be. My recommendation would be to focus on the traditional short-term methods of cost-benefit analysis to determine the impact of this legislation and it would have on national security.

So, I think there are realistic issues to address as if our economy does decline, that will impact on our ability to fund defense and defend ourselves. And if our economy does decline and that impacts on the global economy in general, well that is much more likely to create situations of humanitarian concern and spiraling violence. And so I think that has to be weighed against what benefits in the short term you would actually gain from this legislation.

So I would urge you to make that the focus on your deliberations. What are the costs and benefits in the short terms of this legislation rather than ruminating on what are the long-term implications 30, 40, 50 years down the road to either our ability to ensure our national security or to ensure the readiness and the cleanness of energy and be a good steward of our planet.

Thank you.

[The prepared statement of Mr. Carafano follows:]

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CONGRESSIONAL TESTIMONY

National Security: Not a Good Argument for Global Warming Legislation

Testimony before the Environment and Public Works Committee United States Senate

October 28, 2009

Lieutenant Colonel James Jay Carafano (Ret.)
Deputy Director, Kathryn and Shelby Cullom Davis Institute for International Studies and Director, Douglas and Sarah Allison Center for Foreign Policy Studies, The Heritage Foundation

My name is Dr. James Jay Carafano. I am the Deputy Director of the Kathryn and Shelby Cullom Davis Institute for International Studies and the Director of Douglas and Sarah Allison Center for Foreign Policy Studies at The Heritage Foundation. The views I express in this testimony are my own, and should not be construed as representing any official position of The Heritage Foundation.

Thank you for the opportunity to appear before the committee today and address this vital subject. As President Barack Obama rightly noted in one of his first directives, his "highest priority is to keep the American people safe."[1] He is right. The preamble of the U.S. Constitution states "providing for the common defense" is among the greatest obligations of government. It is, therefore, judicious and appropriate for the committee to consider the national security implications of major legislation that could well affect our freedoms, safety, and prosperity.

The Clean Energy Jobs and America Power Act (S. 1733) has engendered tremendous controversy. Concerns abound about the legislation's adverse economic consequences, and there is skepticism of its affects on world climate trends. I will focus my analysis and observations on the national security implications of attempting to address climate change through a framework established by national legislation.

The premise behind the proposed legislation is that the United States must create a government-run program to reduce the emission of "greenhouse gases," including carbon dioxide (CO_2). The bill would establish a complex energy tax scheme to penalize businesses and industries that emit these gases. Proponents of the legislation have argued that passage is essential to advance U.S. national security. Without the law, proponents argue, adverse climate changes will cause nations to fail, natural disasters will yield unprecedented humanitarian crises, and states will chronically go to combat over the remaining resources. Likewise, they conclude that the legislation will break an "addiction to foreign oil[that] hurts our economy, helps our enemies and risks our security."[2] I disagree with both conclusions.

I conclude that U.S. long-term national security would not be best addressed through legislation that attempts to regulate carbon emissions. This assessment is based on my experience as a serving military officer of 25 years, much of which revolved around strategy and policy planning; a complementary career as a military historian particularly interested in the relationship between armed forces and society and the intersection of military affairs, scientific, business, cultural, and economic history; and as a professor in post-graduate studies whose research and lectures focus on the methods of analysis used to address complex and intractable public policy and national security issues.

In my remarks today I would like to do three things: 1) address each of the arguments for linking global warming and long-term U.S. security interests; 2) discuss what I think should rightly be

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[1] The White House, Presidential Study Directive 1, February 23, 2009, p. 1, at *http://www.hsdl.org/hslog/?q=node/4718* (April 10, 2009).

[2] United States Senate, "Kerry, Boxer Introduce *Clean Energy Jobs and American Power Act*," press release, September 20, 2009, at *http://kerry.senate.gov/cleanenergyjobsandamericanpower/pdf/pressrelease.pdf* (October 25, 2009).

the focus of analyzing the proposed legislation—the short-term security concerns that I believe might arise if the bill becomes law; and 3) suggest some efficacious options for addressing global warming and energy supply issues in the context of national security.

The March of Folly—Simple Answer to Complex Problems

At the root of my concerns over the proposed legislation is that it frames the challenge of global climate change, governance, political violence, and worldwide energy supplies as a single problem susceptible to resolution by management of a single independent variable. Public policy analysis suggests that cannot be correct.

Global environment, governance, and resources constitute a vast, complex system. A system is "any set of regularly interacting factors and activities that has definable boundaries and that produces measurable outputs."[3] The complexity of a system is determined by the number and diversity of interacting components. When systems become overly complex, their behavior cannot be easily predicted by traditional methods of analysis (breaking a system into its component parts and analyzing elements in detail).[4] These systems are described as complex "non-linear." Non-linear environments make it extremely difficult to map the cause and effect between variables. Indeed, in such environments isolating independent variables (a single factor that can be manipulated that will drive the behavior of the whole system) may be impossible. In a complex system, elements are so interconnected and their relationship so multifaceted that their properties cannot be properly understood without assessing their interrelationship with each other as well as their relationship with the wider system and its environment.[5] Offering simple answers to complex problems will not work.[6] This is certainly the case in attempting to understand the relationship between global warming and national security.

While it might feel intuitively appropriate to directly connect the dots between the changing global environment and the human response to global warming, an appropriate complex system analysis would warn against such an approach. The issue of just predicting long-term global climate trends is fraught with controversy and uncertainty. Layering social science models upon our current state-of-the-art climate models to predict complex human responses (including how markets, governments, and communities will respond to anything) is little more than an act of making highly subjective assessments.

Fighting Air—Climate Change and Choice

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[3] Richard L. Kugler, *Policy Analysis in National Security Affairs: New Methods for a New Era* (Washington, D.C.: National Defense University Press, 2006), p. 218.
[4] L.A.N. Amaral and J.M. Ottino, "Complex Networks: Augmenting the Framework for the Study of Complex Systems," *The European Physical Journal*, May 14, 2004, at *http://amaral.northwestern.edu/P ublications/Papers/Amaral-2004-Eur.Phys.J.B-38-147.pdf* (April 13, 2009).
[5] Yaneer Bar-Yam, "Multiscale Representation Phase I," New England Complex Systems Institute, August 1, 2001, at *http://www.necsi.edu/projects/yaneer/SSG_NECSI_1_CROP.pdf* (April 13, 2009).
[6] James Jay Carafano and Richard Weitz, "Complex Systems Analysis:A Necessary Tool for Homeland Security," Heritage Foundation *Backgrounder* No. 2261, April 16, 2009,, at *http://www.heritage.org/Research/HomelandSecurity/bg2261.cfm.*

Attempting to address national security in the context of climate challenge is problematic. The folly of simplicity is perhaps best illustrated in Jared Diamond's highly regarded study *Collapse: How Societies Choose to Fail or Succeed* (2005). Diamond lists a daunting 12 factors that historically contributed to the collapse of a society—and these are only the factors directly controlled by humans.[7] It is worth noting that Diamond is able to detail how this myriad of forces and choices interacted with one another only through the hindsight gained through hundreds of years of historical and archeological research. *Collapse* illustrates the immense difficulty of mapping cause and effect in complex human-environment systems. Additionally, the ability to apply any lessons to the future is complicated by the fact that both human institutions and the natural environment are continually changing and changing each other. His work should, in fact, be seen as a cautionary tale against relying on predictive social science models to interpret complex systems behavior.[8]

History is in fact littered with case studies that suggest straight-line mapping of human-environment interaction is problematic. Since the 1950s, for example, historians have been debating the "seventeenth century crisis" in history as a particularly difficult age.[9] A drop of global temperature, known as the "little Ice-Age" was one of many factors that researchers have cited to account for the political, economic, and military upheaval of the period. Decades of debate, however, have achieved no consensus on cause-and-effect relationships. For example, while the period did see more wars and an increase in human mortality, this age also accounts for the emergence of political stability, scientific discovery and innovation, and the rise of economic productivity in future great powers like Britain and France. If anything, the process of constructing a compelling paradigm has left scholars skeptical of "social-scientific" explanations of history, yet alone suggested any confidence in predicting the future.[10] Anticipating with certainty how climate change will affect human progress is a march of folly.

Indeed, there are many variables other than climate that affect how humans respond to climate change and, in turn, change their behaviors to try to impact climate change and its consequences. For example, while the emission of greenhouse gases has been skyrocketing across the globe in the last decades, political violence has been in decline. This case has been made by at least two independent academic assessments.[11] In the short term, many factors impact on the capacity of humans to govern themselves. On the global scale, human responses rather than long-term environmental trends prove the most dominant.

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[7] Ralph Doty, "Collapse: How Societies Choose to Fail or Succeed," *Human Ecology Review*, Vol. 12, No. 1 (2005), p. 76-77.
[8] Scott E. Page, "Are We Collapsing? A Review of Jared Diamond's Collapse: How Societies Choose to Fail or Succeed," *Journal of Economic Literature*, December 2005, p. 1050.
[9] See Eric Hobsbawm, "The General Crisis of the European Economy in the 17th Century: I," *Past & Present*, 5 (May 1954), pp. 33-53; "The Crisis of the 17th Century: II," *Past & Present*, 6 (November 1954), pp. 44-65.
[10] J.B.Shank, "Crisis: A Useful Category of Post-Social Scientific Historical Analysis?" *The American Historical Review*, Vol. 113, No. 4 (October 2008), pp. 1090–1099.
[11] J. Joseph, et al., *Peace and Conflict 2010* (Boulder, CO: Paradigm Publishers and the Center for International Development and Conflict Management, 2009), p. 1, at *http://www.cidcm.umd.edu/pc/executive_summary/exec_sum_2010.pdf* (October 25, 2010); Human Security Project Research Group, "Human Security Brief 2007," 2008, at *http://www.cidcm.umd.edu/pc/executive_summary/exec_sum_2010.pdf* (October 25, 2009).

In short, viewing climate change and national security together as a single complex model makes little sense. The global climate has always been changing. Adapting to these changes and human efforts to manage their surrounding environment is a permanent feature of human competition. The environment does not cause wars—it is how humans respond to their environment that causes conflicts.

Climate change does not necessarily ensure that there will be more or less conflict. For example, as the Arctic ice melts and the environment becomes more benign, Arctic waters will become more available for fishing, mineral and energy exploitation, and maritime transport. Nations will compete over these resources, but it is how they choose to compete—not the change in the weather—that will determine whether war breaks out.

Furthermore, any changes in the climate, for better or for worse, will occur gradually over decades. Thus, there will be ample time to adjust national security and humanitarian assistance instruments to accommodate future demands. Those adjustments can and should be made with the most appropriate instruments, which might comprise any or all of the elements of national power including diplomatic, economic, political, and informational tools as well as the armed forces.

Supplanting Marketing—Energy Security's Trojan Horse

The Clean Energy Jobs and America Power Act also purports to address U.S. national security by addressing concerns over energy security. Proponents claim that government manipulation of energy markets will reduce U.S. dependence on foreign energy sources and correspondingly increase American security. This logic is also flawed from the start. Global energy markets are complex systems as well. It would therefore be equally prudent to be skeptical of simple cause-and-effect plans.

History is again instructive. In response to the "energy crisis" during the 1970s, the U.S. government took a plethora of actions, implementing a proactive policy to address energy supplies, particularly oil. There were numerous pieces of new legislation, implemented by an alphabet soup of overlapping federal agencies, as well as a host of actions undertaken directly by a succession of presidents. The level of government interference with the nation's energy markets was unprecedented, and these efforts had impacts that usually ranged from ineffective to downright counterproductive.

At almost every turn, Washington took an already challenging energy situation and made it worse through its own policy blunders. The federal government's newly created maze of economic and environmental regulations and the agencies implementing them greatly hampered domestic energy supplies and limited the ability to respond to events. In retrospect, government policies contributed to the harm at least as much as any foreign entity. The errors of the 1970s should serve as a cautionary tale as America again faces similar challenges.[12]

[12] See Ben Lieberman, "Crisis! What Crisis?: America's Response to the Energy Crisis," in James Jay Carafano and Richard Weitz, eds. *Mismanaging Mayhem: How Washington Responds to Crisis* (Westport, Conn.,: Praeger Security International, 2008), pp. 113-129.

Likewise, today legislators should be wary of the desire to impose simple solutions on complex systems and expect the results to be both readily anticipated and inevitably constructive. Even if U.S. energy policies could drive global energy markets in any direction Americans chose (a big "if"), that impact would likely have both positive and negative affects on U.S. Security. For example, although the U.S. is heavily dependant on foreign energy, much of it comes from Mexico and Canada, nations friendly to America and among our largest trading partners. In the short term, one of the most significant impacts of the long-term declining reliance on carbon fuels would be a significant loss to their economies—perhaps a destabilizing one. On the other hand, policies that in the short term might drive up the price of oil would put more money in the hands of countries like Venezuela and Russia, whose foreign policies often clash with the United States. Likewise, adding new transaction costs on energy supplies that increase costs may also unduly weaken the U.S. economy. Simply supplanting market forces is unlikely to prove a panacea for improving U.S. security. The U.S. cannot be confident that by imposing new controls on U.S. energy production and consumption America will become axiomatically less dependent on foreign energy sources.

Simple Answers—Danger Zone for Complex Problems

Indeed, whether the case is trying to link global energy supplies or global temperature to American security, using analysis that suggests employing a single process to guide changes to complex systems might not only be wrong, but could be detrimental—the equivalent of the cure being worse than the disease.

The deleterious effect of using simple mandates to manage complex systems is best illustrated through an examination of the adoption of the Program-Planning Budget System (PPBS) by the Pentagon in 1960s. The premise of PPBS was that linking analysis, planning, strategic decision-making, and the day-to-day management of defense activities into a unified process would make the allocation of resources more rational, relevant, and effective. It failed to achieve that goal. Simply controlling the "machinery" of Pentagon decision-making did not actually allow the Secretary of Defense to produce optimum results, particularly in regards to fighting the Vietnam War. While it empowered Defense Secretary Robert McNamara to impose his "will" upon the decision-making process inside the Pentagon, "planning proved to be an impediment to effective strategic thinking and action, whether one favored hawkish military strategies or dovish political ones...the problem was not that PPBS tried to dictate these choices directly so much as that, by virtue of how it necessarily worked—what planning excluded as well as included—it influenced strongly how others made those choices."[13] In the end, prescriptive policies just implemented bad decisions faster.

The challenge of dealing with global warming through legislative fiat risks a similar fate. By overly structuring the response to complex system problems, the Congress will have an uncertain impact on the system—there is little question, however, that Congress will have a dramatic impact on those elements of the system to which cause and effect can be readily linked. Thus, Congress would be wise to limit analysis and debate over the costs and benefits of the Clean Energy Jobs and America Power Act to factors where cause and effect can be more clearly mapped.

[13] Henry Mintzberg, *The Rise and Fall of Strategic Planning* (New York: Prentice Hall, 1994), pp. 120-121.

The Real Issues for the Energy Act

While the long-term impacts of climate change on national security can be debated, the short-term impact of legislation to curb emissions is more readily apparent. A study by The Heritage Foundation's Center for Data Analysis on a similar companion bill proposed in the House finds that the law would make the United States about $9.4 trillion poorer by 2035. Much of this decline would be from reduced economic productivity and job loss. In particular, under the House legislation there would be 1.15 million fewer jobs on average than without a cap-and-trade bill.[14] Other economic concerns include rising deficits and continued devaluing of the dollar.

A sharp decline in economic productivity would like have a deleterious impact on U.S. security. For example, a collapse in U.S. economic growth would result in even more draconian cuts to the defense budget, leaving America with a military much less prepared to deal with future threats. Indeed, if America's military power declines, there would probably be more wars, not fewer. Likewise, a steep drop in American economic growth would lengthen and deepen the global recession. That in turn will make other states poorer, undermining their ability to protect themselves and recover from natural disasters.

A consequence of passage of this legislation is that it may well create the world we want to avoid. The law would ensure a steep decline in U.S. economic competitiveness and military preparedness. The consequences of a weak America would inevitably lead to a string of national security crises and an undermining of the nation's capacity to deal with natural disasters here and abroad. It would seem in examining the national security implications of climate change, scrutinizing the short-term impact of the legislation would be much more important to address.

Likewise, proponents of the bill must also speak to concerns that any law will not impact global warming in any significant manner. According to climatologist Chip Knappenberger, similar legislation proposed in the House would moderate temperatures by only hundredths of a degree after being in effect for the next 40 years and no more than two-tenths of a degree at the end of the century.[15] EPA Administrator Lisa Jackson concurred, recently saying, "US action alone will not impact world CO2 levels."[16] Additionally, the impact of "managing" greenhouse gases on the environment also remains a subject of great controversy. For example, as Senator Inhofe noted in a floor speech, S. Fred Singer, an atmospheric scientist at the University of Virginia, who served as the first director of the U.S. Weather Satellite Service and more recently as a member and vice chairman of the National Advisory Committee on Oceans and Atmosphere, said that "no one knows what constitutes a 'dangerous' concentration. There exists, as yet, no scientific basis for defining such a concentration, or even of knowing whether it is more or less

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[14] William W. Beach, David Kreutzer, Karen Campbell, and Ben Lieberman, "Son of Waxman-Markey: More Politics Makes for a More Costly Bill, "Heritage Foundation *WebMemo* No. 2450, May 18, 2009, at *http://www.heritage.org/Research/EnergyandEnvironment/wm2450.cfm*.

[15] Chip Knappenberger, "Climate Impacts of Waxman-Markey (the IPCC-Based Arithmetic of No Gain),"MasterResource, May 6, 2009, at *http://masterresource.org/?p=2355* (August 3, 2009).

[16] Press Release, "Jackson Confirms EPA Chart Showing No Effect on Climate Without China, India," U.S. Senate Committee on Environment and Public Works, July 7, 2009, at *http://epw.senate.gov/public/index.cfm?FuseAction=Minority.PressReleases&ContentRecord_id=564ed42f-802a-23ad-4570-3399477b1393* (August 3, 2009).

than current levels of carbon dioxide."[17] In short, if these concerns are valid, the legislation argues for taking on significant short-term risks to the U.S. economy and our security for uncertain gains in environmental quality.

Other Options

I am not suggesting that the United States "do nothing" to protect its national security, ensure abundant supplies of energy, and contribute in a meaningful manner to the stewardship of the global environment. What I am saying is that if we must act with deliberation and speed, we should act where we can act with greater confidence in our outcomes. In this respect, there are options for enhancing national security, improving our ability to adapt to global climate change, and enhancing the dependability and availability of clean energy that the Congress should consider. These would include:

- **Fund defense adeqaequately.** Regardless of how the climate changes or the status of energy supplies, the U.S. will need a military that has sufficient resources to conduct current operations, maintain a trained and ready force, and prepare for the challenges of the future. Spending significantly less than 4 percent of GDP on defense for the next five to 10 years would shortchange the military. Such under funding would ultimately produce a hollow force that is either too small, unable to sustain current operational demands, not ready, or at a technological disadvantage on the battlefield. Congress can provide adequately for national security by making a firm commitment to fund the national defense at no less than 4 percent of GDP for the next 10 years. This commitment would require Congress to add roughly $400 billion to the defense budget for from FY 2009 to FY 2012. A portion of this money would be allocated to ongoing operations, while the remainder should go to the core defense program, with a special emphasis on developing and deploying the next generation of weapons and equipment.[18]
- **Restrain non-defense discretionary spending.** The best tool the U.S. can have to face the future is a strong economy. Imbalances in the level of federal spending and the allocation of federal dollars threaten both the competitiveness and the security of the U.S. Spending not related to defense and post-9/11 operations has increased by 49 percent since 2001, or 5.9 percent annually, compared to 4.2 percent growth under President Bill Clinton. Since 2001, spending on education has grown by 7.5 percent per year, health research by 7.3 percent, and international affairs by 8.0 percent. At a time when defense and homeland security priorities require especially tight non-security budgets, Members of Congress have not made necessary trade-offs. Instead, they have *accelerated* the growth of non-security spending.[19]
- **Use the military appropriately.** Remaining an integral part of the global economy is vital to long-term U.S. national security and the country's continuing economic competitiveness. Rather than attempting to defend, protect, control, or secure any means

[17] Senator James M. Inhofe (R-OK), "The Science of Climate Change, "Senate floor statement, July 28, 2003, at *http://inhofe.senate.gov/pressreleases/climate.htm* (August 3, 2009).
[18] James Jay Carafano, Baker Spring, and Mackenzie Eaglen, "Providing for the Common Defense: What 10 Years of Progress Would Look Like," Heritage Foundation *Backgrounder* No. 2108, February 19, 2008, at *http://www.heritage.org/Research/NationalSecurity/bg2108.cfm*.
[19] Ibid.

of domestic or global production, the greatest degree of security comes from having access to the global marketplace and obtaining goods, resources, and services based on market decisions from friendly suppliers. It is in the vital interest of the United States to uphold the principle of freedom of the seas and to promote and protect the ways and means of free trade among nations acting in accordance with the rule of law. To accomplish this, the United States should retain the capability to use all of the instruments of national power—including military, diplomatic, law enforcement, intelligence, economic, and informational power—in any theater where U.S. interests could be at risk.[20]

- **Reorganize key non-military instruments so that they are more effective.** Again, regardless of how climate and energy supplies evolve, U.S. power must be used effectively to advance U.S. interests. In particular, key non-military instruments such as foreign assistance and public diplomacy are in need of serious reform. Traditional foreign assistance programs have a very poor track record for improving governance, economic growth, or civil society. Of equal concern, U.S. instruments for public diplomacy have atrophied since the end of the Cold War and are in serious need of reform. Neither challenge is being adequately addressed by the current administration.[21]
- **Ensure that any effort to reduce reliance on foreign oil is grounded in policies that are best for the economy.** Reducing oil imports from unstable or unfriendly regimes should be done in a way that minimizes the economic cost to Americans. Policies such as raising taxes on gasoline while mandating or subsidizing expensive or unproven alternative fuels and vehicles lead to large costs with marginal—or even negative—results. The first steps in reducing reliance on foreign oil are to make full use of domestic petroleum reserves and to remove disincentives to investment in oil production from friendly nations. These should be coupled with efforts to encourage diversification away from petroleum, which will be best achieved not by government fiat, but by the private sector–led development of alternatives that can compete in their own right. Domestically, the federal role should be limited to conducting basic research and removing regulatory and tax barriers that impede private-sector innovation. In addition, restrictions on international growth in alternatives, such as the tariffs that limit ethanol imports into the United States, should be eliminated.[22]
- **Use free markets to advance a green energy and environment agenda.** Trade measures in carbon-control legislation may appear necessary for protecting U.S. competitiveness and promoting broader international participation in such schemes. However, in reality, such measures will likely create a more hostile trade environment that costs U.S. firms access to global markets.[23] Rather than using trade policy as a weapon, America should keep markets open. Policymakers—regardless of the shape of any final climate bill—should maintain the integrity and freedom of global markets as a

[20] Stuart M. Butler and Kim R. Holmes, "Twelve Principles to Guide U.S. Energy Policy," Heritage Foundation *Backgrounder* No. 2046, June 26, 2007, at *http://www.heritage.org/Research/EnergyandEnvironment/bg2046.cfm* (October 25, 2009).
[21] Helle C. Dale and James M. Roberts, "State Department Strategy Review Flawed from Start," Heritage Foundation *WebMemo* No. 2659, October 20, 2009, *http://www.heritage.org/Research/ForeignAid/wm2659*.cfm (October 25, 2009).
[22] Ibid.
[23] Ray Walser, "Meeting Energy Challenges in the Western Hemisphere," Heritage Foundation *Heritage Lecture* No. 1079, Delivered March 11, 2008, at http://www.heritage.org/Research/LatinAmerica/hl1079.cfm.

> means to transfer clean technologies, keep international investment flowing, and promote economic growth and prosperity in the U.S. and around the world.[24]

A Better World

Both the advocates and critics of the Clean Energy Jobs and America Power Act share common goals. They want a world where the U.S. remains safe, free, and prosperous. They want a future where the U.S. is a worldwide leader in the stewardship of the global environment, the advancement of freedom and justice, and sustainable growth. My testimony today is intended to help bridge the gap between them—not by rejecting the notion that the U.S. should deal responsibly with the challenges of global climate change, but by suggesting there are real limits to knowing how we can shape the future—and we should focus our initiatives on what we can know.

Thank you for the opportunity to address these vital issues. I look forward to your questions.

[24] Daniella Markheim, "Climate Policy: Free Trade Promotes a Cleaner Environment," Heritage Foundation *WebMemo*No. 2408, April 24, 2009, at *http://www.heritage.org/Research/tradeandeconomicfreedom/wm2408.cfm.*

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Questions for Carafano
Questions from:
Senator Amy Klobuchar

1. The science points to an increase in sea level rise, floods, and changes in temperatures reflecting an overall warming. Can you choose a few specific examples and tell us how these environmental changes, many of which we are already seeing, are politically destabilizing regions?

Making direct linkages between climate change and political instability is difficult. Indeed, as I stated in my testimony, even establishing these linkages with hindsight can be extremely problematic.

The assertion that we are already seeing many of these problems is also unproven. As I stated in my testimony, levels of political violence across the globe are going down, not up. If climate change is impacting levels of violence and instability it is not reflective in major studies. The *Failed State Index*, for example, lists twelve important factors that impact on state stability. All of these factors are dependent on a number of variables including environmental change. There currently is no clear correlation between climate change and the states most at risk to becoming "failed states."

Likewise, as I stated in my testimony it is highly questionable whether making dependable projections about the relationship between climate change and political stability over the long-term is possible. Studies that I have reviewed, including the report conducted by the Center for Naval Analyses, are based on subjective judgments.

2. In the Spring, I traveled through south Asia with Senators Graham and McCain. One of the top concerns I heard from the leaders of the nations we visited was about climate change. Climate change could increase instability and lead to conflict in already fragile regions of the world. In South Asia, India's rivers are vital to sustaining agriculture and Pakistan is heavily dependent on irrigated farming to avoid famine. The Himalayas provide water to both countries, but the water could disappear within a few decades. The United States is working to decrease tensions in this region while climate change is working in the opposite direction. How does this bill put us in a better strategic position to deal with or prevent this type of instability?

I believe this bill could well do substantial damage to the ability of the United States to deal with humanitarian issues, environmental degradation, and security issues worldwide. First, the loss of jobs and decline in economic productivity resulting from implementation of the bill will hamstring the nation's ability to act. Second, the negative economic consequences of the legislation could extend and deepen the global recession. A continued severe global economic decline could well lessen the capacity of others states to deal with environmental, humanitarian, and security challenges.

Senator Lamar Alexander

1. Which is more of a threat to the national security of the United States:
a. American reliance on Chinese, Indian, and Russian technology for nuclear power, scientific innovation and manufacturing capabilities as we would surely see under Waxman-Markey - orb. 0.2 degree increase in the average temperature of the globe? (0.2 degrees Celsius is the climate benefit we'll see if the U.S. institutes cap and trade, but other countries do not)

The greatest threat to US security is any legislation which undermines US competitiveness. I believe this bill could well do substantial damage to the ability of the United States to deal security issues worldwide. The loss of jobs and decline in economic productivity will hamstring the nation's ability to act. Second, the legislation restricts rather than expands America's energy choices. Real energy security comes from open markets that allow the US to develop sources of energy at home and abroad. This bill takes options away…it does not add them. In addition, barriers to innovation such as new taxes and oppressive restrictions to the development of the nuclear power industry and domestic sources of energy are a significant impediment to America's ability to compete in the global market place.

The US can best be prepared to face the future if it maintains a strong and vibrant economy. A strong America will best be prepared to defend its interest and act as a good steward of the environment. This legislation will make the US less well prepared to either deal with global change or compete effectively in global energy markets.

Senator BOXER. Thank you.

I think I will pick up on that point. The message is you cannot predict the future so do not pass complex legislation. I mean, that is kind of what you are saying. And I just want to say, if we had that attitude, we would not have passed the Clean Air Act, the Safe Drinking Water Act, the Endangered Species Act. We would not have passed a lot of things, even the National Highway System. I mean, that was shocking when Ike proposed it.

So, I just do not think that is quite the way I would approach legislation. I think the important point you are making is, of course, we cannot predict exactly what will happen. But we should be conservative here. We should look at what the experts are telling us, which is going to mean I am going to turn to Vice Admiral McGinn.

The Major General and Vice Admiral were just completely on opposite sides, and both of you are very, very clear. So I want to say, from my point of view, obviously, I think I know Vice Admiral McGinn's work on this. The point that Major General was making is that, and I wrote down the notes here, is that there is literally little chance that any of the impacts of climate change would involve a big war between the great powers. I mean, that is what he said. He is shaking his head, so I did get that right.

But is it not true, Vice Admiral, that right now what we seem to be facing more than that fear is instability, terrorism, the kinds of things that Mr. Sloan talked about? The dangers that we are facing right now in two wars where our young people like Mr. Sloan, you know, are giving so much and gave so much, did not have to do with two great powers, they had to do with terrorism and instability.

And is it not true that that threat is exactly what we are worried about here, not the clash between two nations who need oil? You know, I just hope you would expand on that.

Mr. MCGINN. When I was in the Pentagon 50 yards from the American Airlines flight that hit on September 11th, I was not concerned about it being a great power war. There was no mistake in my mind we were at war. We had come to that conclusion, and I had convened my inner circle as the Deputy Chief of Naval Operations for Warfare requirements after the first airplane on a clear September day hit the first tower in New York.

It is about instability. It is about threats to America's well-being, not just measured by the things that happen inside our borders, but how the things that happen inside our border can be influenced by places far away that have an increased level of instability.

I would also point out that while I think the adage is those who ignore the lessons of history are doomed to repeat them, that is an argument that can cut both ways in this debate. And if General Scales and I were sitting here 100 years ago as uniformed members of our respective services, he would be arguing against this damned infernal combustion engine taking out the cavalry and the horses have been really agile and they are good. I would be arguing against putting those damn boilers on perfectly good sailing ships. So this idea of change and predictability goes back in our history.

The thing that is different today is that we have never before on this planet had close to 7 billion people, which we will have in

2011. We have never had the unprecedented level of per capita use multiplied by that 7 billion people. We have never had information technology that gives us an ability to understand what is going on to a much greater level, not with certainty, but to a much greater level that we ever have in the past.

And we have a whole host of indicators, warnings and trends that tell us climate change is bad for national security.

Senator BOXER. I want to ask Kathleen Hicks this question. Again, when Major General Scales was talking about the fear that he had that we would not have enough oil and all the rest, is it not true that our greatest vulnerability in the energy sphere, and I would again quote Vice Admiral McGinn, and I wrote it down, he said our current energy posture is a national security threat if all those, our current energy posture is a national security threat.

Are we not stronger when, for example, America steps out and takes the lead in making jet fuel out of algae, and we do not have to go the sheiks and we do not have to spend $1 billion a day? I mean, is that not what you are looking at, the ability to not be dependent on folks who do not like us?

Ms. HICKS. Senator, I think that really is the crux of the debate here. I think, as Jim Carafano pointed out, everyone is beginning from the same premise of wanting to secure the Nation. What I hear as the fundamental divide is whether or not to embrace change, whether or not lead and adapt, or have that fear of not being able to succeed in doing so.

So, what we are not talking about, really, is the opportunity cost of doing nothing and that opportunity cost is, as you suggest, Senator, that we are tied down by fuel, that fuel is a real day-to-day today, not a future concern only, a today concern for our forces in the field who are tethered to that fossil fuel tail.

Can we change that overnight? No. But if we do not stop working on solutions, we will never get to a different future. We will never shape that future for ourselves.

Senator BOXER. Thank you very much.

Senator Inhofe.

Senator INHOFE. Well, Ms. Hicks, I just really appreciate that last statement that you made, that this is something that is not here now, it is not available at this time, and can we look into the future and say yes, this would be nice when we get to the point that we have all of these things.

To me, I agree with the Chairman, that is the crux of the problem, when we have just this week, well, first of all, let me just stipulate to what the EPA Director said when I asked the question, in the event we pass legislation like this for the United States, is this going to have a reduction in overall emissions? And the answer is no. I think logically we all know that so let us keep that in mind.

But when we have a report that just came out by CRS that says America's combined recoverable natural gas, oil and coal reserves is the largest on earth, but the problem is that 83 percent of it we cannot get to. So let me just ask you a question, Admiral McGinn. Would you not agree that, do not look way down in the future, let us look at tomorrow, let us look at today, we need to have the availability of fossil fuels. Now, is that not true, do you not agree to stipulate to that?

Mr. MCGINN. Senator, I agree, and I would say that the age of fossil fuel has been very, very good to the United States of America starting back with Colonel Drake in 1854 in Pennsylvania discovering this oil. It has been very good. And we are not going to transition off it overnight.

Senator INHOFE. OK, then——

Mr. MCGINN. But it is just that we need to start, and we need to start in significant ways, not small incremental steps.

Senator INHOFE. Well, let me ask you real quick. These have to be short answers because I am operating under this short timeframe. When the statement that you made, General Scales, that there is no scientific evidence to suggest that wars would be propelled and sustained by any power other than fossil fuels, I know you are talking about now and in the near future. Colonel Carafano, do you agree with that statement?

Mr. CARAFANO. You know, I went to Bob, because he is a historian. But my point would be that, in the short term, is that you have to look at what is the competitiveness structure of the United States. And so, my concern is that when you start take away jobs and economic growth, this is the single most important fuel to the defense industrial base.

And that limits your ability, more than anything else, to respond, and that stair steps down. As the United States is a lesser and less capable power, that increases instability. So, it is overall the climate and the economy in the short term which I think creates the kind of world that we are trying to avoid here.

Senator INHOFE. Yes, I understand that. You wanted to say something, General Scales?

Mr. SCALES. Yes, sir. Two quick points. If Dennis and I were to have a conversation 100 years ago over cavalry versus coal powered ships, we would at least have been able to discuss the looming probability that oil-fired burners were just around the corner, that by 1918 or 1919, the great navies of the world had already started to convert from coal.

Senator INHOFE. OK——

Mr. SCALES. My point is this, Senator. I do not see any evidence right now, within the next 20 of 30 years, that some other form of fuel will propel our war making machinery. And my concern is that if we reduce our availability of refined petroleum products over the next 20 or 30 years, that might reduce our ability to go to war. It is just that simple.

Senator INHOFE. Yes, and I agree with that. And I will not ask for a response, Admiral McGinn, because my time is expiring pretty fast here.

The only thing I want to get to here, and I think it is very important for every member of the panel to recognize, at least publicly recognize the fact that we have to have fossil fuels today to fight wars. This is a national security issue. And when we have, we have the largest reserves in the world. And yet, politically, we cannot develop 83 percent of it.

Would you not agree that we need to, if you really feel sincere about not depending upon foreign countries, our enemies, perhaps depending on them for our ability to fight a war, should we not develop our own resources? What do you think, Colonel?

Mr. CARAFANO. Yes, sir.

Senator INHOFE. Is there anyone who would disagree that we need to develop our own resources?

Mr. MCGINN. We do need to develop our own resources. But we need to recognize that there is an opportunity cost. If we place too much of our time and effort and resources into the continuation of our track record of fossil fuel, there is a tremendous opportunity cost for not doing other things that are going to have much, much better returns in jobs in the near term and in national security and prosperity in the long term.

Senator INHOFE. We are talking about fighting a war today, General Scales. You have got to have fossil fuels to do it. Right now, we have fossil fuels, but we are importing fossil fuels from countries that could cut us off. There is a risk there. And when are looking at our opportunity to develop fossil fuels without, not at the expense of anything else, wind or anything else, but to develop them because we have these reserves, can you think of any reason not to do it?

Mr. SCALES. I cannot, Senator. But I would also agree with Dennis, that we need to push the limits of science, we need to find different fuels, we need to find alternative sources, we need to conserve. All of that is absolutely essential for national security. I am worried about the next 20 years when, whether we are fighting a war against a major power or a failed state is attempting to attack us, at the end of the day, we still have to fuel the machines and right now, the only alternative is fossil fuels.

Senator INHOFE. And Senator Warner, do you not think we should develop our own resources?

Senator WARNER. Absolutely. And if I might interject, there has been a lot of discussion here this morning about nuclear power. I was privileged to be a party of a navy where we had over 100 platforms operating safely as they have been throughout almost the entire history of the Naval Reactor Program. We ought to draw on that technology, as the Senator from Tennessee said and put together a strong package as a part of any legislation to help the nuclear industry come back again to the strength it once was in this country.

And it seems to me you have to package that, also, with greater access to this 80 percent. And when you get down to legislating, colleagues, you know it is those types of packages that will balance off the cap and trade which is so intensely felt on part of this hearing room as well as the energy sources of nuclear and drilling on the other side. And it is that type of package you have got to put together, Madam Chairman, to get this bill through.

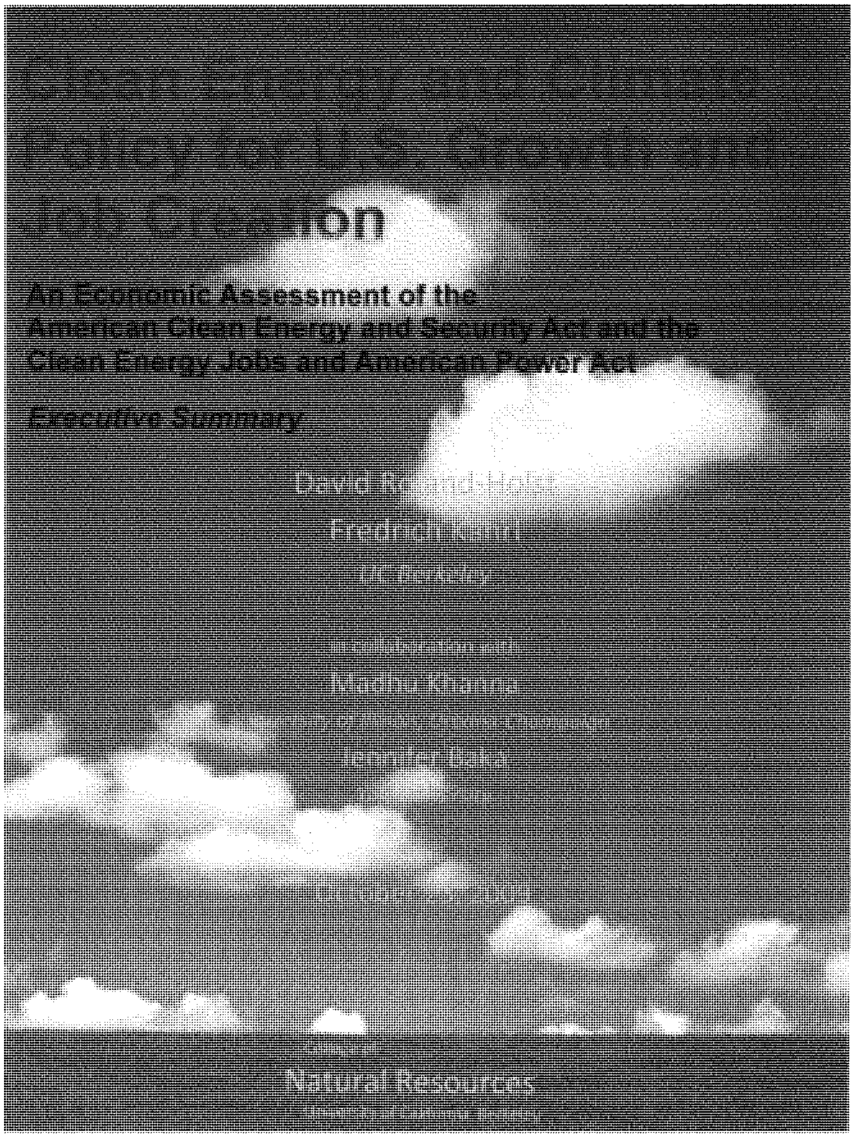
You are at a fork in the road right now as to whether or not Congress is going to lay down the road map for this country, or we are going to just rely on the executive branch and the inherent power of the agencies and the departments.

Senator BOXER. Exactly. I am going to put into the record, without objection, the study that was just done by U.C. Berkeley, University of Illinois and Yale University about job growth, because the Lieutenant Colonel talks about the instability of losing, but there is job growth associated with this. Some studies say 2 million jobs, some say more, some say 1 million jobs. I think it is very key.

And I just have to again say our reliance on foreign oil is what Vice Admiral McGinn, Senator John Warner and others are concerned about. The current energy posture of America is a national security threat now. Not even 20 years later. Now. And I think we have a young man who had his boots on the ground, and I think he has very strong views about that.

Senator Cardin.

[The referenced study follows:]


Clean Energy and Climate Policy for U.S. Growth and Job Creation
An Economic Assessment of the
American Clean Energy and Security Act and the
Clean Energy Jobs and American Power Act
Executive Summary
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Climate change is the greatest challenge facing humanity in the 21st century. Without determined global action to reduce atmospheric concentrations of greenhouse gas emissions over the next four decades, scientific evidence suggests that carbon-intensive patterns of economic growth run a high risk of dangerously altering the earth's climate system.

As a leader in energy technology development and history's largest contributor of greenhouse gases, the United States has an essential leadership role to play in international efforts to mitigate climate change. Exemplifying this leadership, a detailed federal plan to reduce greenhouse gas emissions, the American Clean Energy Security Act (ACES), was introduced into the U.S. House of Representatives in March and passed in June 2009. This analysis provides the most up-to-date state-by-state examination of the economic implications of this kind of comprehensive federal climate policy.

Federal climate policy will have different implications for different states, and should ultimately be designed to account for and address these differences. The U.S. is a complex patchwork of diverse state and local economies that reflect differences in geography, climate, population, resources, and historical development paths. These physical and historical differences contribute to broad spectrum of energy and carbon intensities among states, and these are important factors in determining the economic impacts of a federal climate policy on states.

This executive summary provides general insights from an in-depth analysis of the economic implications of US national climate policy, as these would arise from clean energy and efficiency measures like those in the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act. This comprehensive economic assessment was conducted using EAGLE, a new state-of-the-art forecasting model that projects the long term economic impacts of climate legislation on the U.S. economy. The model details economic interactions within and between each of the 50 states and compares the impacts of combining a limit on carbon pollution with complementary efficiency and renewable energy policies. In addition to many detailed findings for individual states, three overarching conclusions follow from the EAGLE analysis:

Table 1: Main Findings

1. All 50 states can gain economically from strong federal energy and climate policy, despite the diversity of their economies and energy mixes. The states may differ on the supply side, but on the demand side they all have substantial opportunities to grow their economies by promoting energy saving and domestic renewable energy alternatives.
2. Contrary to what is commonly assumed, comprehensive national climate policy does not benefit the coasts at the expense of the heartland states. In fact, heartland states will gain more by reducing imported fossil fuel dependence because they are generally spending a higher proportion of their income on this low employment, high price risk supply chain. Demand side policies make a bigger difference for more carbon-dependent states, and carbon reduction opportunities represent riper and lower hanging fruit.
3. The country as a whole can gain 918,000 to 1.9 million jobs, and household income can grow by $488 to $1,176, by 2020 under comprehensive energy and climate policy. By aggressively promoting efficiency on the demand side of energy markets, alternative fuel and renewable technology development on the supply side can be combined with carbon pollution reduction to yield economic growth and net job creation. Indeed, a central finding of this research is that **the stronger the federal climate policy, the greater the economic reward.**

Every state can accelerate growth by adopting a complete national policy package that promotes three climate strategies in unison: Greenhouse Gas (GHG) mitigation via market oriented restrictions on total carbon pollution, energy efficiency, and renewable energy development. An important finding of this research is that more carbon dependent economies have more to gain from climate action, assuming they adopt balanced policies that combine all three approaches to energy efficiency and clean technology. Given the diversity of initial conditions in this regard (Figure 1), individual states need to recognize the potential of this constellation of policies to promote their growth prospects.

Aggregate Results

Policies as important as the new national climate agenda will have far reaching effects on the state and national economies. Table 2 summarizes aggregate growth effects by state, of adopting a national policy packages like ACES. Measured as percentage variations in real Gross State Product (GSP), these results show changes in aggregate real value added (wages, salaries, and profits) in 2020, compared to the Baseline baseline. The results are variegated, but a few salient findings deserve emphasis. Firstly, implementing the right combination of a Cap and Trade system and complementary measures to promote lower carbon technologies can result in net economic stimulus, for every single state. We see in many states that when market-oriented GHG mitigation is combined with efficient demand and supply side energy policies, the result can be a potent catalyst for economic growth. Even in cases where growth is less than robust, we see nothing like the adverse impacts predicted by industry-commissioned estimates. This is because complementary policies like energy efficiency save enterprises and households money, and this money is spent on domestic and in-state goods and services with higher employment intensity than the import dependent carbon fuel supply chain. Two energy efficiency trends are considered, one conforming exactly to ACES standards, and the other more aggressive. The result is higher employment and income for every state that makes significant progress in reducing its energy dependence.

To fully appreciate the economic effects of climate policy, we must recognize the importance of complementary policies that add efficiency and yield a low carbon, higher growth economic future. Markets alone may not identify the climate change externality and markets for carbon may not provide adequate incentives for innovation and efficiency. To overcome hurdles that limit technology development, diffusion, and adoption, national climate policies include efficiency standards that will provide growth dividends for every state economy.

For most states, growth rates increase with adoption of renewable energy sources. This results from two factors, reduction in long term fossil fuel dependence and exploitation of more efficient alternative energy sources. Fossil fuels are currently depressed by demand side failure in global energy markets, but this situation is temporary and recent IEA and DOE projections foresee a strong and sustained resurgence of fuel prices. By shifting to domestic renewable substitutes, the Western states can reduce their long term external energy dependence and capture more in-state expenditure multiplier effects. In terms of relative efficiency, recent research on new renewable supplies suggests that a 30% RPS can be met from sources with marginal cost below projected fossil fuel alternatives. These savings from "low hanging" fruit in solar, wind, and geothermal sources will also contribute to higher long term regional growth.

Table 2: Job Growth by 2020

State	Thousands		Percent	
	Moderate	High	Moderate	High
United States	918	1,894	.4	.9
Alabama	21	39	.7	1.3
Alaska	1	9	.2	1.7
Arizona	9	24	.2	.6
Arkansas	10	25	.5	1.3
California	120	226	.5	.9
Colorado	11	30	.3	.8
Connecticut	11	16	.4	.6
Delaware	3	7	.5	1.2
Florida	47	78	.4	.6
Georgia	40	70	.6	1.1
Hawaii	4	10	.4	1.0
Idaho	7	14	.6	1.3
Illinois	37	68	.4	.7
Indiana	22	45	.5	1.0
Iowa	14	27	.6	1.1
Kansas	7	22	.3	1.0
Kentucky	10	30	.3	1.0
Louisiana	-6	22	-.2	.7
Maine	6	12	.6	1.2
Maryland	34	71	.8	1.7
Massachusetts	22	40	.4	.8
Michigan	42	37	.6	.6
Minnesota	19	38	.5	.9
Mississippi	8	19	.4	1.0
Missouri	18	29	.4	.7
Montana	5	13	.7	1.8
Nebraska	12	38	.8	2.6
Nevada	9	17	.4	.9
New Hampshire	5	7	.5	.7
New Jersey	13	11	.2	.2
New Mexico	5	15	.4	1.2
New York	77	126	.6	1.0
North Carolina	17	65	.3	1.0
North Dakota	4	11	.7	1.8
Ohio	35	61	.4	.7
Oklahoma	-2	20	-.1	.8
Oregon	13	26	.5	1.0
Pennsylvania	46	78	.5	.9
Rhode Island	5	8	.7	1.1
South Carolina	21	36	.7	1.2
South Dakota	5	10	.8	1.5
Tennessee	2	20	.0	.5
Texas	44	165	.3	1.0
Utah	8	21	.4	1.1
Vermont	4	8	.9	1.5
Virginia	25	50	.4	.9
Washington	1	13	.0	.3
West Virginia	10	31	.9	2.8
Wisconsin	20	28	.5	.7
Wyoming	6	20	1.3	4.5

Table 3: Real 2020 Household Income and GSP

State	Income (2008$)		GSP Percent	
	Moderate	High	Moderate	High
United States	488	1,176	.2	.7
Alabama	547	1,261	.4	.9
Alaska	1,165	5,801	-.1	2.6
Arizona	53	283	.0	.2
Arkansas	457	1,230	.4	1.1
California	735	1,477	.4	.7
Colorado	425	1,138	.0	.4
Connecticut	717	1,011	.3	.4
Delaware	398	1,416	.2	.9
Florida	303	615	.3	.6
Georgia	702	1,362	.4	.9
Hawaii	610	1,464	.3	.8
Idaho	431	1,149	.3	1.0
Illinois	508	1,137	.2	.6
Indiana	476	1,219	.3	.8
Iowa	686	1,501	.5	1.2
Kansas	229	1,182	.1	.7
Kentucky	267	1,133	.2	.9
Louisiana	-219	1,582	-.4	1.0
Maine	550	1,317	.5	1.1
Maryland	1,022	2,172	.6	1.2
Massachusetts	738	1,356	.3	.7
Michigan	667	750	.4	.5
Minnesota	579	1,240	.3	.8
Mississippi	289	889	.2	.8
Missouri	446	892	.3	.7
Montana	599	1,736	.4	1.4
Nebraska	927	4,120	.6	2.7
Nevada	471	1,025	.3	.7
New Hampshire	573	726	.3	.4
New Jersey	196	-92	.1	-.1
New Mexico	516	1,309	.0	.7
New York	902	1,580	.4	.7
North Carolina	230	1,159	.2	.9
North Dakota	1,048	2,683	.5	1.5
Ohio	452	992	.3	.7
Oklahoma	47	986	-.6	-.1
Oregon	399	941	.3	.7
Pennsylvania	637	1,092	.4	.7
Rhode Island	700	1,172	.5	.8
South Carolina	650	1,259	.5	1.0
South Dakota	784	1,602	.6	1.2
Tennessee	-129	406	-.1	.3
Texas	442	1,814	.0	.8
Utah	523	1,435	.2	.8
Vermont	816	1,535	.6	1.2
Virginia	554	1,325	.3	.7
Washington	-195	105	-.1	.1
West Virginia	684	2,737	.5	2.5
Wisconsin	513	749	.3	.6
Wyoming	4,884	9,862	1.2	4.0

Federal Climate Policy: An Overview

U.S. federal climate policy has converged around the creation of a national cap and trade (C&T) system, with a substantial program of research, development and demonstration (RD&D) and a number of mandatory alternative energy, energy efficiency, and other measures to complement the GHG emission reductions achieved through the C&T system. A detailed plan to implement this system was introduced in March of 2009 by Representatives Henry Waxman and Ed Markey through the American Clean Energy and Security Act (ACES), and passed in June 2009.

In September 2009, Senators John Kerry and Barbara Boxer introduced a Senate version of climate legislation, the Clean Energy Jobs and American Power Act (CEJAPA). This analysis takes ACES provisions as its starting point, but its conclusions will be broadly relevant for any similar comprehensive national policy that includes both carbon and energy policies.

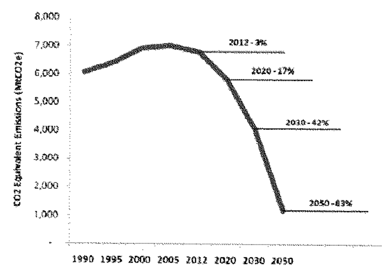
ACES includes the following four major provisions:

1. A cap and trade system (Title III) with a cap that steadily declines over time and a system to allocate allowances.
2. A requirement that electric utilities meet 20% of their sales through renewable energy by 2020, with utilities able to meet a certain portion of this obligation (25%) with efficiency (Title I).
3. Aggressive energy efficiency standards for new buildings, appliances, and vehicles (Title II).
4. A substantial program (in the hundreds of billions of dollars) to support RD&D in clean energy and energy efficient technologies, funded in part through CO2e allowances (Title IV).

The ACES cap is designed to be comprehensive, covering 84% of U.S. GHG emissions by 2016. Regulated entities must hold one allowance to emit one metric CO2e ton of any GHG included under the cap. Allowance obligations can be met by reducing emissions, through allowances saved ("banked") from a previous period, by purchasing allowances, by purchasing international offsets, or by using allowances from countries that have comparable systems. ACES places a ceiling on international offsets, but grants the EPA administrator the flexibility to adjust that ceiling.

The ACES cap has two primary targets (Figure 1): economy-wide GHG emissions must be reduced by 17% from 2005 levels by 2020 and by 83% from 2050 levels by 2050. Two intermediary targets require a 3% reduction in 2005 GHG emissions levels by 2012 and a 42% reduction from 2005 levels by 2030. The CEJAPA has proposed a more aggressive 2020 target of 20%, but has adopted the same 2050 target.

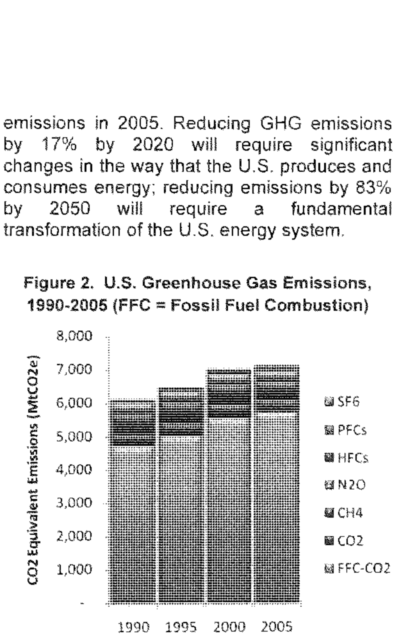
Figure 1. GHG Emission Reduction Targets under ACES



Source: GHG emissions data are from EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1980-2007," April 2009.

U.S. GHG emissions are and have historically been dominated by fossil fuel combustion (Figure 2), accounting for 80% of total GHG emissions in 2005. Reducing GHG emissions by 17% by 2020 will require significant changes in the way that the U.S. produces and consumes energy; reducing emissions by 83% by 2050 will require a fundamental transformation of the U.S. energy system.

Figure 2. U.S. Greenhouse Gas Emissions, 1990-2005 (FFC = Fossil Fuel Combustion)



Source: EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1980-2007," April 2009.

Within fossil fuel combustion, GHG emission sources are more diffuse. The two largest emission sources — coal-fired electricity generation (33%) and motor gasoline (20%) — accounted for roughly 53% of energy-related GHG emissions in 2005. The next largest sources of energy-related GHG emissions each account for less than 10% of total energy-related GHG emissions. In recognition of this distribution, ACES includes both a comprehensive cap and specific measures that target both the electricity and transportation sectors.

Policies Assessed

A comprehensive climate policy package can be complex. It is also generally the product of detailed negotiations that take account of very heterogeneous economic interests. For this reason, the current analysis aims to provide overall guidance by considering only the most salient components of a national climate initiative. To improve visibility for public and private stakeholders regarding economic impacts of a comprehensive national climate policy like that currently being discussed, the EAGLE model assesses a package consisting of five generic policy types:

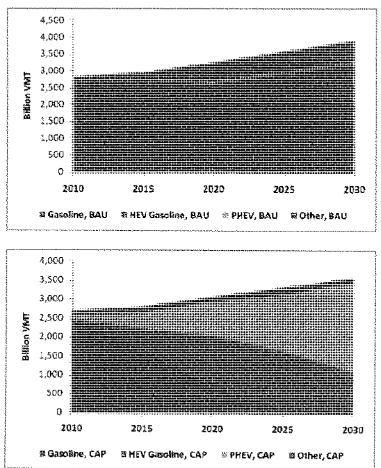
Carbon Emission Reductions that reflect market based measures to restrict total atmospheric emissions of CO2. In this analysis, we do not consider detailed design characteristics for such a mechanism, but only impose a national limit on total emissions and assume that a mechanism of trading pollution rights leads to a market premium that provides incentives for energy conservation and investments in more efficient technology.

EAGLE is an economic forecasting model. To estimate patterns of technology adjustment in the underlying energy economy, we draw upon results from the MARKAL national energy simulation model. These provide inputs to EAGLE in the next four policy categories, each dealing with a different dimension of energy use.

Transportation includes changes in the energy requirements and fuel mix of the light duty vehicle (LDV) and heavy duty vehicle (HDV) fleets. Transportation adjustments include shifts in the fuel and fuel economy composition of the LDV and HDV fleets. For the LDV fleet, the primary shift captured in MARKAL is toward greater adoption and use of hybrid electric vehicles (HEVs) and ultimately plug-in hybrid electric vehicles (PHEVs). Figure 3 shows the changing composition of LDV vehicle miles traveled (VMT) over time in the

MARKAL results. For HDVs, we consider only heavy truck results as there are no major changes in the fuel economy or per vehicle emissions of other HDVs in the MARKAL results. The primary shift in heavy trucks is toward more efficient vehicles, with a small shift toward biodiesel. In the Policy case, by 2030 roughly one-third of all heavy truck VMT is accounted for by post-2020, high efficiency vehicles, whereas in the Baseline case none of these vehicles are adopted.

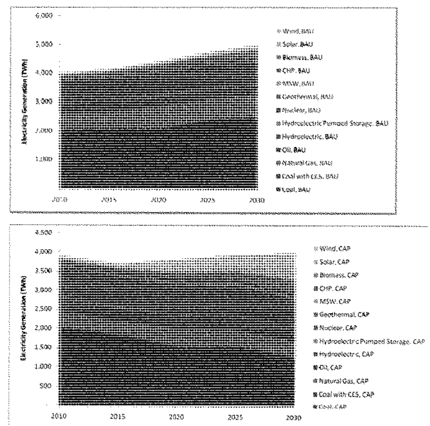
Figure 3. Composition of LDV VMT, 2010-2030, Baseline and Policy Cases



Notes: "Other" here includes E100, all-electric, diesel, CNG, and LPG-powered vehicles.

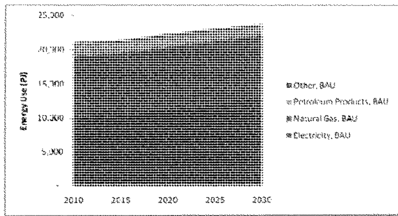
Electricity Generation under a carbon cap will experience changes in the composition of the mix of electricity generation resources, including shifts toward low or zero carbon energy sources, including coal-fired generation with offsetting CCS. Two main resource shifts are notable in the MARKAL results (Figure 4). First, with a significant ramp up in generating capacity over the 2010-2030 period biomass, solar, and wind power account for roughly one quarter of total national generation by 2030. Second, in the Policy case a small but significant amount of coal with CCS begins to come online. These two shifts displace coal and natural gas generation, with the majority of CO_2 emission reductions coming from reductions in coal-fired generation.

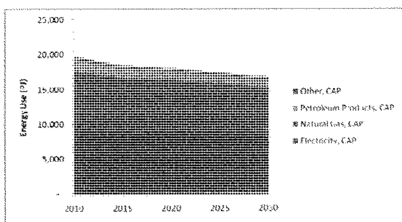
Figure 4. Changes in the National Generation Mix, 2010-2030 Baseline and Policy Cases



Residential and Commercial Energy Efficiency includes changes in the energy requirements of residential and commercial buildings, appliances, and electronics. Residential and commercial energy efficiency includes improvements in the efficiency of buildings, appliances, and electronics that use electricity, natural gas, and petroleum products. The MARKAL results also include the introduction of solar water heaters on a larger scale.

Figure 5. Changes in the Total, Aggregated Residential and Commercial Energy Use, 2010-2030 Baseline and Policy Cases





As shown in Figure 5 (residential and commercial aggregated), residential and commercial energy efficiency gains in MARKAL result in the flattening out of electricity demand and absolute reductions in natural gas and oil use relative to Baseline. As a result, total residential and commercial energy use declines in absolute terms (by about 15%) from 2010 to 2030 in the Policy case, and total residential and commercial energy use in the Policy case is about 30% lower than in the Baseline case.

Sequestration and Offsets include terrestrial carbon sequestration and landfill gas projects. Sequestration and offsets include four major categories: agricultural (mostly soil carbon sequestration), livestock (mostly manure management), forestry (mostly changes in forest management), and landfills (landfill gas capture and generation). Table 4 shows estimated abatement potential for domestic sequestration and offsets, aggregated by region.[1]

Table 4. Annual Abatement Potential for Sequestration and Offsets by Region, Year 2030

Region	Abatement Potential ($MMTCO_2$)				
	Agriculture	Livestock	Forestry	Landfill	Total
Midwest	4	15	16	20	55
Northeast	1	3	12	7	25
Plains	3	13	7	25	61
South	2	9	30	24	72
West	3	13	58	25	137
TOTALS	12	4	236	100	351

Economic Diversity

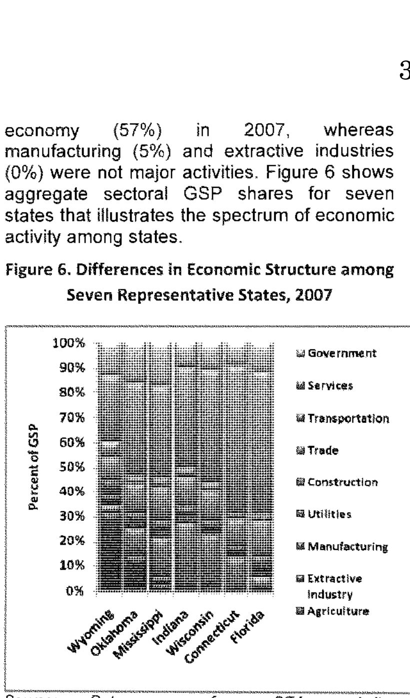
The U.S. is a patchwork of diverse state economies that reflect different geography, climate, resource endowments, and historical development paths. Differences in economic structure contribute to differences in energy and carbon intensity among states.

At an aggregate level, the most significant differences among state economies are in the shares of extractive industries, manufacturing, and services as a share of gross state product (GSP). More than 30% of Wyoming's GSP in 2007, for instance, was generated by coal, natural gas, and oil extraction, whereas manufacturing (3%) and services (26%) played much smaller roles. Indiana had the highest GSP share of manufacturing (26%) in the U.S. in 2007 and a moderately large services industry (40%), but negligible resource extraction (0%). At the other end of the spectrum, services dominated the Florida

[1] Note that these estimates show significantly less offset abatement potential than the bill allows. Also, this analysis assumes no international offsets are used. Thus this could be considered a low-offset scenario. We conclude that high levels of offsets are not economically necessary, but if more low-cost offsets are indeed available, the CO2 cap could be met with higher net benefits.

economy (57%) in 2007, whereas manufacturing (5%) and extractive industries (0%) were not major activities. Figure 6 shows aggregate sectoral GSP shares for seven states that illustrates the spectrum of economic activity among states.

Figure 6. Differences in Economic Structure among Seven Representative States, 2007



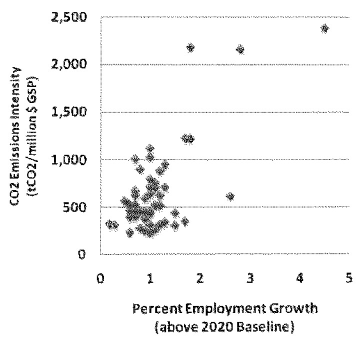
Source: Data are from BEA website, http://bea.gov/regional/index.htm#gsp

These differences in economic structure will play an important role in how states adjust to the requirements of a federal climate policy. For instance, the economic impact on states that are more dependent on fossil fuel extraction will depend on the feasibility and cost-effectiveness of carbon capture and storage (CCS), the timing of shifts to alternative energy sources, and the effects of a range of energy and climate policies on fossil fuel prices. Manufacturing is typically more energy intensive than services, and states where manufacturing is a larger share of GSP will have to give greater consideration to managing the impacts of a federal climate policy on retail energy prices.

However, focusing on industry and commercial energy use overstates both the diversity of states and the costs of reducing carbon intensity. In most states, consumer demand is over half of GSP and in many states much more so. In terms of household spending patterns, state-by-state differences are much smaller, and the scope of energy efficiency improvements much more comparable. State's may have different initial levels of CO2 intensity in demand, but the tools of demand side management are the same. Moreover, historical record of leading state clearly shows that efficiency improvements are not merely feasible, but represent a potent source economic growth. Over three decades (1972-2006), California's energy efficiency measures saved households $56 billion and created 1.5 million additional jobs with $45 billion in additional payrolls. More than anything else, it is these savings opportunities from energy efficiency that drive the positive economic results across the board.

The results of our EAGLE assessment send an even stronger message about demand side opportunities. As Figure 7 indicates, **the greater the initial level of CO2 intensity in overall state demand, the larger will be the employment dividend to that state from adopting a comprehensive package of national climate policies**. This is true because demand side policies make a bigger difference for them, and carbon reduction opportunities represent riper and lower hanging fruit for investments in efficiency and renewable energy.

Figure 7: State Initial (2006) CO2 Intensity and Employment Effect (2020) of Climate Policy



Sources: Energy data are from the EIA website. Economic data are from BEA website, http://bea.gov/regional/index.htm#gsp.

Methodology

The primary tool for this economic assessment was the Environmental Assessment in GeneraL Equilibrium (EAGLE) model, a state-of-the-art forecasting tool that details patters of demand, supply, energy/resource use, employment, income, and emissions across each of the 50 United States. Full technical documentation of the model is available from the authors.

Data Sources

Economic Data

The primary economic data resource used to calibrate the EAGLE model is IMPLAN, a nationally consistent collection of economic data that detail patterns of supply, demand, and resource use for over 500 sectors of the economy in each of the 50 states. Based on a twenty-year data management initiative begun by the US Forest Service, IMPLAN offers the most up-to-date detailed data on economic structure of the US economy.

Emissions Data

A large collection of the latest official statistics were used to calculate a state-by-state, sectoral greenhouse gas (GHG) emissions inventory for the EAGLE model. Basic GHG emissions inventories are not yet available at a state level,[2] much less at a sectoral level, in the U.S. In constructing an emissions inventory for the model we use a number of data sources and assumptions, documented more fully in the overall project documentation. To our knowledge, these estimates represent the first state-by-state, detailed sectoral emissions inventory for the U.S. Here we summarize the constituent data sources.

The U.S. Energy Information Administration (EIA) maintains detailed data on fossil fuel CO_2 emissions, with CO_2 emissions estimated from both national and state-level fossil fuel use data. The U.S. Environmental Protection Agency (EPA) maintains a more comprehensive national inventory that covers all GHG emissions, but lacks detail at a state and sectoral level. In building the CO_2 portion of the EAGLE GHG inventory we make use of both EIA and EPA data. The non-CO_2 portion relies exclusively on EPA estimates.

EIA and EPA both use five major sectors to categorize CO_2 emissions from fossil fuel use: Transportation, commercial, electric power, industrial, and residential.

EIA's state-level estimates of CO_2 emissions by sector are based on detailed assessments of coal, natural gas, and petroleum product use

[2] See the EPA's State Greenhouse Gas Inventories, http://www.epa.gov/climatechange/emissions/state_ghginventories.html.

by state. In order to maintain consistency between the EIA's national and state-level CO_2 emissions estimates, we adjust state-level CO_2 emissions by fuel to match estimates of national CO_2 emissions by fuel. The data that we ultimately use as inputs are the EIA's state-level CO_2 emissions estimates by major sector, adjusted to match the EIA's national estimates of CO_2 emissions by fuel.

Our economic data is from 2006, and we update EIA's 2005 CO_2 emissions data using EIA national CO_2 emissions estimates for 2006. This approach assumes that the sectoral structure of CO_2 emissions remains unchanged from 2005 to 2006. Final fossil fuel CO_2 emissions inputs are listed in Table 4.

Table 4. Final Fossil Fuel CO_2 Emissions Inputs Used in the EAGLE GHG Emissions Inventory

	Transport	Commerce	Electric Power	Industrial	Residential	Total
Coal	0	9	1,949	182	1	2,141
Natural Gas	32	159	312	410	256	1,169
Petroleum	1,758	47	91	606	89	2,591
Total	1,790	215	2,351	1,198	346	5,901

Note: Totals do not necessarily add due to independent rounding.

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Senator CARDIN. Thank you, Madam Chair. And let me really thank this entire panel not only for your testimony today but for your service to our country. We very much appreciate everything that you have done. I think this panel has been extremely helpful to us in dealing with this subject.

And it is always an honor to have Senator Warner with us. There was no greater champion of national security here in the U.S. Senate, and I consider myself fortunate to have served with Senator Warner in the U.S. Senate. So, it is a pleasure to have you back before our committee.

I think the point that Senator Warner raised, the point that our Chairperson raised, about national security on our energy sources here, we can do everything that we can to deal with oil, we just do not have enough of it. I have joined with Senator Alexander in saying that we have to do a better job with nuclear. We need the whole package for the sake of our national security, including the much stronger emphasis on alternative and renewable energy sources and better conservation.

So, Senator Warner has brought to our attention many times the direct threat that our energy policies pose to our national security, including climate change and sea level increases and the effect that it will have on our military facilities.

One thing to me is somewhat shocking is the significant increase in expenditures by our military on energy. It has gone up 500 percent over the last 9 years. And that is just funding countries that are our most challenging are far as our military is concerned. So, it is counterproductive to our own national security, and we have to do a much better job with the energy policy.

I want to take advantage of this panel, if I might, on an area that has not gotten as much attention, and that deals with the fact that we do allocate in this bill for preventing international deforestation and allowances for international adaptation, which some say, well, gee, is that not just humanitarian aid by America? I see that as part of our energy strategies and our international strategies, and it very much has a national security focus.

I want give it first to Admiral McGinn, if you would. How important is it for the United States to speak about the financing of global climate change issues and adaptation and deforestation funds as we go toward an international agreement, we hope, in Copenhagen, but as we work with other countries? How important is it for the United States to show leadership on the financing of these issues?

Mr. MCGINN. I think it is very important, Senator. I mean, there are some that over 50 years ago would have said that the Marshall Plan was primarily a humanitarian relief program. But in fact, it was at the core of creating a new world order and creating a much more secure place for the United States and for Europe.

In terms of this new challenge, there are so many good things that come from investment of time and effort by the military, by the whole intergovernmental process, in resources, in technical assistance, that can create relationships with nations and with the militaries that can really help to make a difference to mitigate and to adapt to the potential effects of climate change. So, I think it is a very, very important part of our strategy going forward for our defense and national security strategy.

Senator CARDIN. Thank you. Senator Warner, you have negotiated with a lot of our friends around the world, and you know how much they look to the United States as far as leadership on issues. As far as helping to finance the consequences of global climate change internationally, how do you see the United States as far as leadership is concerned?

Senator WARNER. Well, I think the United States should be a leader. But we have got to be mindful that we are in very competitive world, and so many of our principal competitors, as was clearly brought out in this excellent dialogue today, do not follow the framework of laws and human consideration in this country.

So, we have got to strike a balance. We would not want to put forward legislation that is going to put us at a disadvantage in this competitive world. So, you were right when you raised the point Copenhagen is the forum. Maybe not this sessions coming up in December, but there will be a subsequent, and a subsequent, and that issue has got to be agreed upon by all nations for a fair playing field.

Senator CARDIN. You know, that is an extremely important point. Even if we have the most successful outcome from Copenhagen that many of us hope for, that we establish targets and a mechanism to achieve those targets, and we have the financing and enforcement, it is the beginning. It is not the end of this process. There is a lot more work that is going to have to be done in all of our countries, including, after we pass this bill, we still have a lot more work to be done.

Thank you, Mr. Chairman.

Senator LAUTENBERG [presiding]. As acting chairman, I know that Senator Alexander is next.

Senator ALEXANDER. Thanks. Thanks, Senator Lautenberg, thanks very much.

I want to thank the witnesses for being here, and I want to take particular advantage of Senator Warner being here and try to rely on his experience, both as a legislator and his military experience. And Admiral, you may have something to add here, too.

I would like to look at the next 20 years. As I think Senator Warner knows, I agree with him that climate change is real, that humans are causing it. My problem is with the solution. I think the economy-wide cap and trade has some real disadvantages.

One, it does not work with fuel. It raises the price of fuel, but it does not reduce much carbon. We have had plenty of testimony on that, and that is 30 percent of carbon. Something else has to deal with fuel.

Second, it is a problem with manufacturing, which is under stress anyway, because it is going to raise the costs in manufacturing, and manufacturing may, probably will, go overseas looking for cheap energy. And that is a problem for us.

And three, it deliberately raises the price of energy when our goal for ourselves and for the world, in my view, ought to be cheap energy so we can have a prosperous economy and so we can relieve hardship for poor people.

So, I have suggested a different way for the next 20 years, which I believe is simpler and will work, which does not include a national energy tax, and I believe there is broad bipartisan agreement for it.

No. 1, build 100 nuclear plants in 20 years. No. 2, electrify half the cars and trucks in 20 years. And No. 3, four mini-Manhattan Projects of the kind the six would talk about to make solar costs competitive, to find ways to recapture for coal plants, to make electric batteries that will take our cars 400 miles instead of 100 miles, and to find ways to recycle used nuclear waste in a way that does not isolate plutonium.

By my computations, if we did that, at the end of 20 years we would be producing about 40 percent of our electricity from carbon-free nuclear, we would be producing maybe 5 or 10 percent from solar and wind and other forms like that, about 10 percent from hydroelectric, about 25 percent from natural gas, and we would actually reach the Kyoto goals for 2030 without a national energy tax.

But my problem is, and this is my question for you, every time we have a panel here, we talk about wind, which is 1 and 1.5 percent of our electricity, we talk about solar, which is promising but negligible. Even in Germany, where they are head over heels for solar, it is 1 percent of their electricity. We talk about biomass, which scientists are reminding us, if you haul hundreds of trucks, I mean, just to create the equal of one nuclear plant in electricity, you would have to continuously forest an area 1.5 times the size of the Great Smoky Mountain National Park with hundreds of trucks today. So, all of those things are a long way away.

Yet we have China with 132 nuclear reactors. We have Japan, two a year, Russia, two a year, other countries moving ahead of us. And we have not built one in 30 years.

So, if you were again the Secretary of the Navy, and we were going to war, and we had created a nuclear navy 60 years ago, and it was doing exactly what we wanted, and we had had thousands of sailors living on top of reactors safely for 60 years, would we stop building nuclear ships and start subsidizing sailboats?

I mean, why is that panel after panel never mentions nuclear power except reluctantly when we invented it, it is available, and we know we can build 100 plants in 20 years with Presidential leadership?

Senator WARNER. Well, Senator, you have no stronger proponent of urging the Congress and the country to accept the reality that we have to move to a vastly expanded base of our energy from nuclear power. It is the zero emitter of greenhouse gases, as you well know.

But let us come back to it. I think we agree on that. But you raise a larger question. How much can we do in terms of legislation now, and how much must we do in subsequent years?

I think this very complicated subject is not unlike building a great cathedral. You are going to lay a foundation, hopefully in this session of Congress, and in the next maybe begin to build on it slowly. Because it is an enormous educational process that has to be undertaken with the Nation's public, which inherently believe they want cleaner air and cleaner fuel and this and this and this, all of which is part of this evolution of energy and climate change.

But let us look at the means by which we can find, in this session of Congress, a package of steps, good, forward looking steps, one being nuclear on which we can agree, and put them together, and then recognize what we have to do in the ensuing years.

It is going to be like building that cathedral, and frankly, I will not be around when the final capstone is put on that cathedral. But that is the way great edifices and great things are achieved. I know the Chairman feels very strongly about trying to put forward some legislation. I just hope that you can package together that which you can agree on.

But let me make one thing clear. It has to be bipartisan. It really does. It has to be a concurrence of all of us reflecting the views of our diverse citizenships, the needs, and in this complex world of competition, we have got to remain strong.

It is easy for me to sit here and not having to vote as do you, but I am most respectful for what you are trying to do in this committee and in other committees, and I think you can achieve some milestone in this Congress. I hope you succeed.

Senator BOXER [presiding]. Well, the plan is that we get our bill out, and it gets married up with other bills. And Senator Kerry is working with Senator Lindsey Graham now, which is really very encouraging, to try and get to that sweet spot that you described. That is what we are trying to do.

Now, next on my list, I will go through, Specter is not here, Klobuchar, so it would go to Senator Whitehouse next.

Senator WHITEHOUSE. Thank you, Chairman.

First, let me extend a particular welcome to Senator Warner. I could not be happier that he is back. It was a pleasure working with him during the time that we overlapped, and he represents, represented, both represents and represented, I think, our institution at its very, very best. So it gives us honor that you are back here, and it gives me great personal pleasure that you are here. Thank you for the many kindnesses that you showed me as a new Senator finding my way around this place. You reached across the aisle and were extraordinarily generous and I appreciate that.

Senator WARNER. Well, I thank you Senator. And do not forget what I told you one day in private. Look at your future.

Senator WHITEHOUSE. Why do we not leave it private? That would be embarrassing.

[Laughter.]

Senator WHITEHOUSE. Admiral McGinn, I want to clarify a point because some of the comments, I think, might leave the suggestion that it is our intention that we turn our naval forces, for instance, to sail power or to turn away from fueling battleships with whatever the best fuel is for their tactical purposes.

As I understand it, this bill does nothing to interfere with the military's selection of the appropriate—the most appropriate fuel, to carry out its mission. The focus of this particular panel, as I understand it, is that the missions that our military will have to address will be more dangerous, more frequent, more widespread, if we cannot control our climate and if we cannot control our role in intoxicating our atmosphere with carbon pollution.

And the means that we go about doing that, as I understand it, is to put a price on the pollution that, and it is just major polluters, that the major polluters have been getting away with for free for years. And by putting a price on it, you allow the market to adapt to the real cost of their product, as opposed to that implicit subsidy that they have been enjoying.

But nothing about this says that an aircraft carrier has to put up sails and can only go in the wind. If it is running on a nuclear plant, if it is running on bunker fuel, whatever it is running on, as I understand it, is not affected by this legislation. Is that correct?

Mr. MCGINN. As I understand it, it is not. You are right, Senator. I would commend to the committee's study a speech that was given on the 14th of October this year by the present Secretary of the Navy, Secretary Mabus, in which he outlined some very bold and far reaching measures that the Department of the Navy, both the Navy and the Marine Corps, were undertaking to lower the carbon boot print, if you will, to increase the portfolio of energy choices and the energy efficiency with which we use those choices in a very, very great way. It is a terrific speech, very specific on the goals, and I did not see a sail on an aircraft carrier once in that speech.

I will say that on the 13th of October, the Naval Air Test Center, Patuxent River, fired up an F–404 engine, the engine that powers the F–18 Super Hornet, powered by bio-based fuel. And they intend to fly a Super Hornet that has become affectionately known as the Green Hornet in April of this year, entirely fueled by bio-based fuel.

Are we going to suddenly convert all of our military applications from petroleum to bio-based? No. But we are starting to take some measures. And every percent, every gallon, that we can get to break our—the stranglehold of petroleum on our Nation, is that much further down the road we are toward better security.

Senator WHITEHOUSE. And on that subject, could you just touch briefly on the national security consequences of our national dependence on a foreign oil supply? The military could move off it and decide that it is only going, you know, in a time of real emergency, that it would only use domestic fuel services. But the cost to the general economy, if we were interrupted in our foreign sources of fuel, I think would be fairly considerable. Would you, how do you evaluate that?

Mr. MCGINN. I do not think it would be, in the overall sense of national security, it would be a terrible situation to find ourselves in where we had to allocate increasing amounts of existing available domestic fuel oil to military purposes, and as you say, it would devastate our economy and thereby have a terribly bad effect on the overall national security.

Senator WHITEHOUSE. So, our present reliance on foreign oil is a national security risk?

Mr. MCGINN. It is.

Senator WHITEHOUSE. Thank you.

Senator BOXER. Thank you, Senator, very much.

So, in the absence of a Republican, we will go to Senator Udall.

Senator UDALL. Thank you, Madam Chair.

Senator Warner, it is great to have you back here with us again. A number of Republican Governors from California to Connecticut are reducing greenhouse gas emissions in their States as part of binding programs. Other Republican Governors in States like Utah and Florida have also embraced action on climate change. As you well know, John McCain is one of the original fathers of climate change legislation in the Senate. And you played a key role when you were in the Senate and on this committee, and also what you are doing today.

Do you believe there is bipartisan support? You mentioned the word bipartisan, and you really emphasize that. Do you believe there is bipartisan support in the country for legislation to set binding national targets to reduce greenhouse gas pollution and to move to a more secure energy future?

Senator WARNER. Senator, I very definitely believe that. As a consequence of having the privilege of conducting many, many town meetings, I suppose that is participating in many, many town meetings and talking to a number of universities, I visited Colorado recently and the Air Force Academy and the University of Colorado, politics really does not feed into these discussions. It is a thirst and a desire for a better understanding of what this all about. They feel the need. They want to participate. They just need an avenue and some leadership.

And currently, the Governors of the several States are providing strong leadership, together with the legislatures. And particularly the university and college structure, the educational institutions. That is why I think it is so important for the Congress to join in providing some uniformity.

Because you take the average power supplying mechanisms in our country, they do not serve just one State, they serve six or seven or eight States in a region. And the complexity of the environmental initiatives in the various States drive them to the, you know, common denominator somehow that they can figure it out.

So, the need for this road map which is really the province and the province alone of the U.S. Congress is really needed as early as possible. And I agree with you 100 percent. I commend the Governors for their leadership, and there is a strong feeling of bipartisanship as we traverse the land and listen to the people.

And thank you for your courtesies. Under the Ethics Laws, I cannot communicate with any of you when I am in your States. But I try to get in and out without causing you any problems.

[Laughter.]

Senator UDALL. I bet you are glad you are not doing town hall meetings in this climate we have right now.

Senator WARNER. Well, I am. But I must tell you, in sharp contrast, they are very constructive.

Senator UDALL. Yes. Yes. Let me ask you about the situation, and I think you mentioned this in your testimony, that we are facing right now. The Administration sees that climate change is a major issue, and we have heard from the Under Deputy Secretary here, and we have heard that in many ways from this panel.

So, they are moving forward with an aggressive effort at the EPA, which is very limited under the Clean Air Act as to what they can do. But they can do a lot, and they are going to try to regulate 7,500 of these business entities that eject more than 25,000 tons of carbon dioxide.

The other side of it, and that is what I would like you to talk to, is, you know, if we do nothing, then the Administration proceeds down that path. If we move forward, there is so much we can do in the Congress to help the various sectors, to help people that are at the lower end of the scale, all of those kinds of things.

Do you think the more prudent path is really the path of Congress acting rather than this more blunt approach that the Administration is taking?

Senator WARNER. Very definitely. As I said, we are at a fork in the road, and right now we just cannot leave it to the executive branch. It seems to me that Congress has got to lay down a map.

But it would seem to me, and I may be little presumptuous, the President has been a strong advocate of this whole concept. But at some juncture, and it is up to the leadership of the Congress, of course, but it would seem to me the President ought to join in as these several committees are beginning to try to strike a consensus among the bills, and say, look, I have left to you the initiative, but this is a framework of the essential points I deem necessary in such package of legislation as the Congress may tackle in this last remaining months of this session of Congress.

I would hope that he would look upon that. I realize that the health bill is all consuming at the moment. But this is equally important. You have Copenhagen when the eyes of the world are going to be examining on where is the United States at this session.

Senator UDALL. Thank you, that is very constructive. And thank you to all of the panel for your service. Thanks, Madam Chair.

Senator BOXER. Yes. And Senator Warner, I think there will be some good news out of this committee next week. So, stay tuned.

Senator WARNER. I will be staying tuned.

Senator BOXER. In terms of moving forward with this work that we have to do because the window of opportunity is closing. It really is. And we have wasted some time.

So, here is the situation. If nobody else shows up, the order is Merkley and Lautenberg. OK?

Senator Merkley.

Senator MERKLEY. Thank you very much, Madam Chair, and thank you to members of the panel.

I would like if you all could comment on a different aspect of the national security energy puzzle, and that is the funds that flow overseas when we purchase energy, and those funds that go to Venezuela, that go to Saudi Arabia, and according to some reports, end up in the hands of folks who do not have particular sync, they are not in sync with the United States, with all of our values and objectives.

So, maybe we could explore a little bit your thoughts on the national security issues that are raised by the $1 billion we spend overseas on oil.

Ms. HICKS. Senator, let me take the first stab at that. I think you have really hit the nail on the head with your question. When we cede control of our energy strategy to foreign actors, and in many cases it is quite small subset of foreign actors, we really put our own national security at great risk given our incredible reliance on it. So, again, I think you have got the problem quite right. It is not just the states, it is what happens to the funds at the sub-state level.

We have, or course, in the internal environment, Al Qaeda and other transnational terrorist movements that prey upon various sources of funding, and the more that we can do to control that aspect of the problem, the better off we are in terms of our security.

So, a comprehensive energy strategy by the United States is incredibly important to solving that problem.

Mr. CARAFANO. Senator, I think the question you have to ask yourself is if the price of taking money out of the hands of bad actors crippling your economy in the short term. And if the answer is yes, then you have to ask yourself is the cure worse than the disease? And then you also have to ask yourself, what other alternative mechanisms can we use to keep money from going into the hands of bad actors? And that has to be, I think, part of the discussion.

Senator MERKLEY. Yes, Vice Admiral.

Mr. MCGINN. 2008, Senator, was, or should have been, a wake-up call for America and our dependence on foreign oil. We shipped $386 billion outside of our economy to pay for our oil bill, to pay for our, as President Bush said it in his State of the Union several years ago, to pay for our addiction to oil.

And as you rightly point out, this goes to, in many cases, state-funded oil companies. That money finds itself to the Hugo Chavez Fund and other actors in the Middle East that are counter to our interests and to our beliefs, in many cases.

So, what should we have learned? Oil was $140 a barrel. It is about half that, or maybe a little bit more, right now. It will go up. There is no doubt about it. No matter how much drilling we do in this country, no matter how much domestic we try to squeeze out, the price of oil will go up. And every $10 increase in a barrel of oil costs the Department of Defense nearly $2 billion that is taken out of our ability to pay for other things, war fighting capability.

That should be the wake-up call. We cannot let it happen again. We have got to start moving in a different direction.

Senator MERKLEY. One of the questions that I think it is worth wrestling with is whether we should have a coherent national strategy to reduce our importation of oil. We affect it indirectly through this bill in all kinds of ways, but not in terms of targeted milestones.

But we had testimony earlier today that changing just our passenger transportation strategy could reduce the amount of oil we import by 44 percent. And I think about what we could do in air transportation, where biofuels can substitute, freight transportation where there is a non-profit working in Oregon that reshapes all the air foils in trucks and puts automatic air pressure in the tires, which boosts mileage, home heating oil which can be converted to natural gas.

So, I just want to pose the question, should we have a coherent national plan, if not to reduce our oil imports to net zero, maybe to reduce them by 80 percent to a level where no particular supplier could exert either a huge oil shock to our economy or a huge national security risk by constraining our access?

Mr. SLOAN. Senator, I think the more important question is not reducing imports, per se, but is lessening our use of fossil fuels by making ourselves more efficient and kind of embracing clean energy technologies that invigorate the economy as a whole. Restricting fuel market access is not where we should be headed, I do not believe. I think really the focus is on kind of innovating within, using our resources more efficiently and progressing from there.

Senator MERKLEY. Any other thoughts?

Senator.

Senator WARNER. Well, let me give you an example. When I visited the Air Force Academy, they put this booklet together for my visit and actually for other reasons, but it really sets forth how the Air Force Academy as an island, right there in Colorado, is going to making and conserving its own energy. It is going to run itself, totally free of the domestic availability of energy around it.

I find that all forms of initiatives are out there within the private sector and in the public sector, working. What they need is a framework plan. And you have got to devise a stream of funding. How many times in these town meetings have people said to me, if we could only get a small grant, we have got an idea which we can develop and contribute. Of course, the cap and trade system is to be that funding stream.

But if you can just begin to at least find a funding stream to help, whether it is nuclear energy or others, get started and get off the ground now.

Senator MERKLEY. Thank you so much. My time is up. I will just close by noting that I appreciate your comment, your testimony, Senator, that the young leaders at the Air Force Academy really get this issue. And that certainly corresponds with what I have seen on university campuses in the State of Oregon.

Thank you.

Senator BOXER. Thank you so much.

Senator Lautenberg.

Senator LAUTENBERG. Thanks, Madam Chairman.

I do want to say publicly about how inspired we are by the leadership of Senator Boxer. She has decided that this cause of ours deserves as much attention as it can get and persisted, and here we are, and thus a lot of time invested, but that is what we have to do.

And I thank all of the witnesses for being here. I disagree with one or two, which we will try to get to.

Senator, I was in the Army. So, we can smile at one another. John Warner and I shared something. Senator Whitehouse said you gave him information as a young man. You gave me information, leadership, as a mature man, a little more than a young man. We both wore the uniform of our country in World War II. I think you also spent some time in Korea or with the Korean War. So, our experiences may or may not be relevant.

But when I see what is happening, and General Scales, I thank you for your service to country as well as Admiral McGinn and the other little, see what happens when you are so young? We do not get to quite acknowledge your service. But each of you is owed a debt of gratitude by our country.

General Scales, in your remarks, you talked about a climatic crisis precipitating human friction, mass migration, you outlined things that might happen. But you say the problem is that even if such disasters occur, they will not be a serious cause for war, particularly a war between a major competitor and the United States.

And I look at what is happening now, as we all see, about what is happening in Afghanistan, and how madmen can bring us in time to our knees, even though we have the weapons, we have the troops, we have bravery, we have systems. But here they are. And there are more of them than there are of us in the final analysis. They are not afraid of our guns. They are not afraid of our might. And they do not give a damn about their lives.

So, what kind of a war can be precipitated? I see a disaster. And Admiral McGinn, we have had a chance to meet and talk in the past. Is there going to be a restructuring of the Navy that is going to cost lots of money? Is it worth it if we have to do it?

Senator Warner, do you see a major restructuring of equipment?

Senator WARNER. My good friend, I thank you for your comments on how both of us were privileged to wear the uniform in years past, and I certainly enjoyed the work that we did together.

I would defer to this wonderful witnesses right here. I have appeared with her a number of times, and she works under the tutelage of a wonderful professional, Secretary Flournoy, who I met recently, and they are looking forward 4 years into how are United States military and Quadrennial Defense Review are to be restructured, the policies revised to confront the very thing that you mentioned.

Just a little historical footnote. In World War II, we did not experience that type of suicidal attacks in any way near the percentage we see now, except for the last battle in Okinawa and subsequent conflicts. But this is something we have go to confront, this suicidal tendency——

Senator LAUTENBERG. Confront or even acknowledge. Because the price that these people are willing to pay is so enormous, as we see now in Afghanistan and have seen in Iraq. And when people are trying to say they do not care so much about their lives, but they all care about their families' lives, and they will do anything to reach our shores if their countries are underwater. And I think that is what is going to precipitate——

Senator WARNER. Ask Secretary Hicks. She is working on that 4-year progression, together with others in your department, on how we are going to change strategies to confront the very thing that the Senator raises.

Ms. HICKS. Senator, we are about three-quarters of the way through our Quadrennial Defense Review which, as you know, is the congressionally mandated review we undertake at the beginning of every Administration.

We look out actually about 20 years and we look, in particular, at sort of 5-year time lines, 5 years out, 5 years beyond that, et cetera. And the world you are depicting, we do see in the future.

I do not want to say that to undermine the very important point Major General Scales made, which is that we do think state-on-state warfare is something to worry about in the future. We in no way dismiss or diminish the importance of preparing the United States, and through the capabilities of the United States military, for handling that kind of challenge.

But the fact of the matter is the world is simply more complex. And as the Secretary likes to say, our Secretary likes to say, this is not about fighting the wars we wish we were fighting. This is about fighting the wars we are in and the wars we will have to fight in the future.

That will require quite a bit of rebalancing of our forces. That does not necessarily mean substantial shifts in funds, because some things cost more than other things. But it does require substantial shift in mind set and how we think about the types of challenges in the future.

The fact of the matter is that there are lots of different trends out there that are worrisome. Climate change is really an accelerant to a lot of trends we already see that could—it threatens the most those states that are least able to cope with those sorts of challenges to population, to water resources, to migration, to disaster. And as such, it can create, as we have already seen in some states where there is a lack of governance, it creates these ungoverned spaces, these opportunities for actors that counter U.S. interests to really come in and start to take over a population.

Senator LAUTENBERG. Thank you. Madam Chairman, General Scales wants to——

Senator BOXER. Yes. Yes.

Mr. SCALES. Could I just? A couple of quick points.

Senator LAUTENBERG. Yes, please.

Mr. SCALES. First of all, I do not see the future as being a cataclysmic state-on-state type of war either. What my point earlier was is that what motivates the Taliban is not being denied oil or the rising tide of rivers in Afghanistan. It is an ideological religious motivation, not the fact that they are economically deprived.

And the other point, if I may, just add the point about fuel consumption. Yes, state-on-state warfare does demand large amounts of fuel. But I have been to Afghanistan. I was there last year. And if you look at the amount of fuel that is needed to fight a non-state enemy or an enemy like the Taliban, it is enormous.

That tether that fuels helicopters, and MRAPs and M1 Abrams and all the rest of that is an enormous fuel drain. And it would be unfortunate that if we had our ability to produce, refine and transport that fuel to a theater of war.

Senator BOXER. We are going to bring this to a close. I so appreciate, Senator Lautenberg, your questioning, because you have just made the case for our bill. We need homegrown fuels because it will always be important. And that is why in my State, where they are turning, you know, we are seeing jet fuel being produced from algae and I think, Vice Admiral, you discussed a bio-mass fuel that is being used.

When it is homegrown, we do not have to worry about getting it from parts of the world that our friend Mr. Sloan had to go to, you know, and risk his life on a daily basis and win all those incredible commendations.

I just want to say what an incredible panel this has been and how energized I am. Even those of you who did not agree with our approach.

Lieutenant Colonel, I just have to say, I know that your testimony was written on Heritage Foundation stationery, and you said you were speaking for yourself. But I have to say you did them proud today with your, you know, the way you presented it.

But there is a flaw in what you said. And I do this as a friend so that we can continue this conversation. To put out a scare testimony that there is going to be scarcity and shortages and lack of jobs, that is totally untrue. The opposite is true.

We are going to have a different mix of energy. That is true. And we are going to see jobs moving into other sectors across the line. But there are going to be more jobs here, more businesses here, better jobs that you cannot export.

And yes, it has a cost. There is no doubt. Thirty cents a day for the average family. And you know, that cost does not take into account what we save when we avoid the ravages of global warming, one of which is what you are talking about, all of you today, most of you today, not all of you, which is the real possibility that we are going to have to go to war and send young people to war because of the instability caused by the climate and the refugees and the water problems and all the famine and all the things, the droughts that go with it.

So, yes, the studies show that there will be more jobs, that we will not have shortages, we will free ourselves from imported oil slowly over the time. But all of you have been so great.

And I want to thank my staff. I was so taken with Vice Admiral McGinn's comment that they already turned it into a chart.

[Laughter.]

Senator BOXER. They are remarkable using solar energy. No, I am only kidding.

America's current energy posture constitutes a serious and urgent threat to national security, militarily, diplomatically and economically. This is a quotable phrase. And it is what I believe, it is what a lot of members of the committee believe, it is certainly what Senator Kerry believes. It is why we place such stock in your testimony. And part of our wonderful coalition in support of our work is a huge number of young people and people all the way up the age stream who believe that we are doing the right thing for our national security.

So, again, my deepest, deepest thanks. And I am also going to place in the record a press release and statement from the CIA that they are opening up a Center on Climate Change and National Security. They view this as a serious threat now, and they want to get ready for it as the years go on.

So thank you very much. We stand adjourned. We are going to come back at 2:15 p.m. for our next panel.

[Recess.]

[The referenced press release and statement follows:]

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CIA Opens Center on Climate Change and National Security

September 25, 2009

The Central Intelligence Agency is launching The Center on Climate Change and National Security as the focal point for its work on the subject. The Center is a small unit led by senior specialists from the Directorate of Intelligence and the Directorate of Science and Technology.

Its charter is not the science of climate change, but the national security impact of phenomena such as desertification, rising sea levels, population shifts, and heightened competition for natural resources. The Center will provide support to American policymakers as they negotiate, implement, and verify international agreements on environmental issues. That is something the CIA has done for years. "Decision makers need information and analysis on the effects climate change can have on security. The CIA is well positioned to deliver that intelligence," said Director Leon Panetta.

The Center will assume responsibility for coordinating with Intelligence Community partners on the review and declassification of imagery and other data that could be of use to scientists in their own climate-related research. This effort draws on imagery and other information that is collected in any event, assisting the US scientific community without a large commitment of resources.

The new Center does more than bring together in a single place expertise on an important national security topic—the effect environmental factors can have on political, economic, and social stability overseas. It will also be aggressive in outreach to academics and think tanks working the issue. The goal is a powerful asset recognized throughout our government, and beyond, for its knowledge and insight.

Senator BOXER. I want to welcome all of you. You are panel three in our hearing marathon today. I am so very pleased. This record that you are going to make today is so very important. And today we are going to hear from utilities how you feel about what we are contemplating doing here in the Kerry-Boxer bill.

So, we are going to go from this way to this way, and we will start with David Crane, President and Chief Executive Officer, NRG Energy.

Welcome.

STATEMENT OF DAVID CRANE, CHIEF EXECUTIVE OFFICER, NRG ENERGY, INC.

Mr. CRANE. Thank you, Madam Chairman, and thanks for this opportunity to discuss legislation on climate change which is an issue which we consider to be the transcendent challenge to our generation of American leadership.

And I want to salute you and the member of your committee, Senator Kerry and your staffs for starting this important work in the Senate.

As a major fossil fuel user, we have long recognized the challenge of climate change to our company. But rather than oppose it, years ago we chose to transform that challenge into an opportunity, and we are 3 years into our $15 billion RepoweringNRG Program, which involves advanced nuclear, wind, solar, biomass and post-combustion carbon capture projects in active development across the country,

To date, we have spent hundreds of millions of dollars on this effort. As a merchant power company, we have no rate paying public to pass that cost onto. Indeed, we can only recover that money if we control costs and risks and make these low carbon projects work in the marketplace.

But today's market does not put a price on carbon emissions. Right now, the easiest and cheapest thing for us to do to is to emit all the carbon produced as a byproduct to our generation process into the atmosphere, and we are allowed to do that for free.

So, for our investments in these new low and no carbon technologies to work, the Senate needs to act now to make carbon emissions part of the economic equation for NRG as well as for the rest of the economy.

Your draft legislation, I believe, tacitly recognizes that effective Federal climate change legislation will, in fact, be our national energy policy for the next two generations. In that regard, I want to compliment you and this Administration for your focus on encouraging renewable generation, and I would note that NRG has a multi-billion dollar investment plan for renewables already well underway.

But I would also caution, with respect to renewables, that there are inherent issues of intermittency, limited-scale expense and geographic constraints. There are serious limitations. We need to build a zero carbon base load foundation under our wind farms and solar fields, and that foundation is new advanced nuclear power.

And it is zero carbon nuclear that will provide the juice for our personal transportation system based on a nationwide fleet of electric cars, dramatically reducing both tailpipe emissions and the transfer of American wealth to the oil exporting nations.

Right now, NRG's $10 billion 2,700-megawatt South Texas Project is on the short list to receive DOE loan guarantees. We are confident that it will succeed, be built on budget and be on line in the later part of the next decade, along with at least two of the other projects presently under consideration by the DOE.

But three new nuclear plants by 2020 does not a nuclear renaissance make. We need 75 new nuclear units by 2050 simply to maintain nuclear power's current share of electricity production. And to double it, we need to build at least 150 new units.

The nuclear title in your bill is a good start. But in addition to support for worker training and R&D, it needs more support for domestic manufacturing capability, siting on suitable Federal land, additional but shorter lived loan guarantees, and efficient approval processes to safely handle a much larger volume of projects.

The de-carbonization of the electricity sector is the single biggest step we can take to reduce greenhouse gas emissions. But simple math tells me that if the goal is 83 percent carbon reduction by 2050, we need also to de-carbonize the private transportation sector as well.

Your bill, again to its credit, recognizes the importance of the electrification of the transportation sector but is, I believe, too modest in its goals. We need legislation that will incent a commercial foothold strategy that will quickly capture a significant market share for electric vehicles among actual American consumers in key American cities that themselves have taken meaningful steps to deploy an electric car ecosystem right now.

In addition to the huge benefits in tailpipe emission reductions, the electrification of our transportation sector will provide the cure to our national addiction to foreign oil and will substantially reduce the $400 billion of annual wealth transfer that currently takes place from the U.S. to the oil producing nations. Keeping that $400 billion at home is important to me, not just as the CEO of NRG, but as an American.

As to the general market-based format of your bill, we support all of its key structural elements. But we would respectfully suggest four areas for your potential consideration.

First, avoid under allocating transitional allowances in the power sector in order to assure the ability of the power sector to deploy game changing clean technologies. Second, act affirmatively to limit the EPA's ability to use existing Clean Air Act provisions to regulate greenhouse gas. Third, increase the supply of offsets and act now to establish EPA criteria to ensure a supply of early offsets that will be valid for compliance. And fourth and finally, ensure the market stability reserve program is large enough to provide a suitably firm cap on allowance prices.

Thank you.

[The prepared statement of Mr. Crane follows:]

Testimony Before the Senate Committee
on Environment and Public Works

On

S. 1733
The Clean Energy Jobs and American Power Act

David Crane
CEO
NRG Energy, Inc.

October 28, 2009

Thank you for this opportunity to appear before you on the topic of climate change. Because this is the critically urgent issue that informs everything we do from national energy policy to national security, I think of climate change as the transcendent challenge of our generation of American leadership.

As a major power generation company with a large fleet of conventional fossil fuel plants across the country, NRG has long recognized the challenge that climate change legislation represents to our industry but rather than resist based on narrow and short-sighted self-interest, we chose four years ago to turn the challenge of climate change into opportunity. By embracing the emerging and, in the case of nuclear, the re-emerging low carbon technology innovations that have been developed by America's entrepreneurs and inventors over the past several years, we set a course to achieve a first mover low carbon advantage in our industry. Accordingly, we are now three years into our 10 year $15 billion *Repowering*NRG program, a program that will substantially reduce the carbon intensity of our fleet with advanced nuclear, wind, concentrated solar, solar PV, biomass and post-combustion carbon capture projects.

To date, our company has spent hundreds of millions of our shareholders' money on this development effort. As a merchant power company without regulated customer rates, we can only recover that money if we control costs and risks, and make the technology work in the competitive market. But of course neither the competitive market nor the fully regulated electricity market puts a price on carbon emissions. We are allowed to emit all we choose to into the atmosphere for free. This is why the Senate needs to pass legislation in order to make carbon emissions part of the economic equation for NRG and the rest of the industry.

The timing is particularly acute right now. For NRG, after 3 years of development, permitting, etc., many of our projects are ready or nearly ready to break ground. But for many of our projects to make that jump from millions of dollars spent on development to the billions invested in construction, the Senate first needs to pass a comprehensive climate bill. This is because due in part to the dramatic decline in fuel and wholesale electricity prices over the past year the economics of many of these projects depend partially or totally on their being a price imposed by the United States Government on emitting carbon into the atmosphere.

That, I would suggest respectfully, is how the EPW Committee and the Senate as a whole should think about the task at hand. I encourage you to view your work as a bipartisan mission to find a climate change framework that will unleash the power of American capitalism and the innovative genius of America's entrepreneurs. Certainly I can assure you that if you provide a sound framework, NRG will do everything we can within our capability to bring the promising low carbon energy technologies being developed and demonstrated around our country to full scale deployment, at a cost that allows the US not only to compete in the global economy, but to win.

As you address that task, and seek to improve on the effort begun in the House earlier this year, comprehensive federal climate change legislation designed to reduce our carbon emissions by 80% by 2050 will, in fact, be our national energy policy for the next two generations. The House bill recognized this to a degree by including a Federal renewable energy standard in AR 2454.

But a national renewable policy, such as a federal RES, while it may be laudable, is not by itself an effectively comprehensive low carbon national energy policy. Renewable resources are a major part of our low carbon future, but their inherent issues of intermittency, limited scale, expense and geographic constraints are serious limitations. In fact, we need to build a zero carbon base load foundation under our wind farms and solar fields. That foundation is new advanced nuclear power.

Right now NRG's $10 billion, 2700 MW STP 3&4 project is one of the four projects under due diligence at the DOE for the all-critical federal loan guarantee, which was authorized by the Energy Policy Act of 2005 and has been administered in an admirably bipartisan way by the DOE through the transition from the Bush to the Obama Administration. We are highly confident that our project will proceed successfully through the DOE loan guarantee and NRC regulatory approval process, that it will be built on time and on budget and that it will be on line in the later part of the next decade, supplying inexpensive, reliable and safe base load power to 2 million Texan homes – and with zero carbon emissions or, for that matter, air emissions of any kind. We expect at least two of the other three projects currently before the DOE to begin operation in the same time frame.

Three new nuclear power plants by 2020, while an important first step in the right direction, does not a nuclear renaissance make. If you assume that all 104 nuclear reactors currently operating in the United States have been retired by 2050, that means we need approximately 75 new nuclear units over the next 41 years simply to keep nuclear power's share of electricity production near 20%. If we want to double the nuclear share of power production to 40% in order to accommodate demand growth and realize a greater carbon benefit, we are going to need to build about 150 new nuclear units.

There is a big gap between the three to four new plants currently working their way through the system to construction now and 150. In my view, we have no hope of getting anywhere near 150 new units over the next 41 years unless we have an effective nuclear title as part of comprehensive climate change legislation in 2009. That title must embrace new nuclear as a fundamental building block of our 21st century national energy policy, and provide the pragmatic, essential policy tools that are needed to realize the laudable intentions laid out for new nuclear power in the Kerry- Boxer bill -- tools that are needed in addition to a price on carbon for nuclear to succeed. Those tools must address the key commercial constraints to a nuclear renaissance, and include worker training, expanded domestic manufacturing capability, transitional loan guarantees for project financing for a second wave of new plants, and efficient and safe regulatory approval processes capable of handling a much larger volume of projects.

Nuclear, renewables and, let us not forget, carbon capture and sequestration, can transform NRG's fleet and the US power sector from high carbon to low carbon in the next 30 years. That will address the 40% of US carbon emissions that come from the power sector. But another third comes from the transportation sector, and more than half of that comes from light cars and trucks and simple math tells me that, if the goal is 80% carbon reduction by 2050, that means we need to aim for near total decarbonization of both the electric and transportation sector.

The Boxer-Kerry bill recognizes the importance of decarbonization of the transport sector through electrification but is too cautious in what it proposes. Planning and grants are well and good, but what we need to do is start building an electric vehicle ecosystem in several major cities and city clusters across the country right now. In other words, we need to focus on a commercial foothold strategy that will quickly capture a significant market share for electric vehicles in key American cities that themselves take steps to develop a coherent electric car urban ecosystem. This needs to be combined with provisions that foster entrepreneurial, campaign-based, commercial efforts to drive rapid adoption of electric vehicles by actual American customers.

Electrification of our transport sector is, of course, not just a major step forward in our effort to decarbonize American society, it means much more in terms of the enhancement of national security and the preservation of national wealth. The electrification of our transportation sector will provide the cure to our national addiction to foreign oil and will keep at home in the United States a substantial portion of the $400 billion of wealth transfer that currently takes place every year from the United States to the oil producing nations.

Let me turn from what should be added to the bill to commenting on what is already in the Boxer-Kerry bill. First, we want to salute you, Chairman Boxer, along with Senator Kerry, the members of this Committee and your staffs for starting this important work in the Senate.

Let me make it clear that we support the general framework of this bill. By that, I mean a declining cap on carbon emissions, a market-based flexible compliance system, and a combination of free allocations and auctioning of allowances. Auction revenues and some of the free allowances are used to help buy down the initial cost and risk of low and no-carbon technologies. Additional allowances and revenues are used to buffer the impacts of compliance costs on end use consumers. And a large number of offsets and other measures are intended to ensure that those costs do not become excessive. This bill has all of those features. However, in my view, the current draft would be more effective with modifications to several of those key provisions:

First, the bill appropriately recognizes that the most important source of investment in clean technologies is the private sector, and in the power sector that means power companies themselves. The transitional allocation of carbon allowances to the power sector is incredibly important in enabling US electric companies actually to invest in the scale deployment of clean technologies. As a merchant generation company, NRG would face a stark choice under climate legislation without enough transitional allocations for merchant coal companies. Earnings that we are spending today on aggressively decarbonizing our fleet would instead be spent buying more allowances in the EPA auction, leaving us unable to deploy at scale the low carbon technologies needed to meet the legislation's aggressive emission reduction goals. An adequate supply of transitional allocations to merchant coal companies will allow us to invest our way to a low carbon future; while helping ensure against carbon "windfalls" from merchant coal receiving excessive transitional allocations. Similarly, rate-regulated utilities need the bill's LDC allowances so that they, too, can invest in costly new technology without creating the rate shock that would harm customers and lead state utility commissioners to slow down their spending on new technology.

Given the importance of this issue, the House bill's overall level of power sector allocations were at a bare minimum for us. We certainly appreciate the maintenance of the basic power sector framework in the Kerry-Boxer bill. However, the set aside of some 10% of all allowances in the Senate bill for deficit reduction, while done more or less fairly or "across the board", does create a real problem for companies like ours that are attempting to invest tens of billions of dollars in new, clean power plants in the upcoming decade. We think the most promising solution to this problem is to carefully improve the bill's features for avoiding both under-allocation and over-allocation in and across sectors, and we look forward to working with members of this and other committees in exploring such improvements in efficiency and fairness, while maintaining the basic allocation approach.

Second, we are concerned with the very real risks to our economy and, we believe in the longer run, the climate that will result from EPA regulating greenhouse gases under the current Clean Air Act - as it is poised to do as early as next Spring if you do not act first. There are two basic problems with using the Clean Air Act's provisions for greenhouse gases– first, it can only mandate the use of technologies to reduce emissions, but cannot provide the positive incentives for rapid development and deployment of those technologies that would be provided by comprehensive climate legislation. Second, the solutions it can mandate for greenhouse gases are likely to both be highly expensive and environmentally relatively ineffective. To prevent both of these problems, the Senate must not only pass comprehensive climate legislation before next Spring, it must also affirmatively prevent the EPA from regulating GHGs under the Clean Air Act in ways that will do more harm than good in the power sector. The House bill does this. The Senate bill should, too. We believe there are a variety of approaches to fix this problem in an environmentally responsible way, and look forward to working with members on developing a Senate solution.

Third, the bill increases support for the broad early deployment of carbon capture and sequestration, which we believe is crucial for global success in reducing carbon emissions to acceptable levels. We appreciate the significant effort and innovation in this area your bill has made, and as we work through the significant details of your new provisions, we will commit to help with further improvements based on our own ongoing efforts and experience with post combustion carbon capture technologies.

Fourth, we believe that the cost containment provisions of the bill can and should be improved, in three key ways:

- Along with other members of USCAP, we support the ability of covered entities to use at least 2 billion tons of offsets, made up of no more than 1.5 billion tons of either international or domestic offsets. The bill's limitation on domestic offsets international offsets is too narrow, and we believe will increase the risk of allowance prices being unacceptably high.

- We also believe it is critically important to take steps that will increase the supply of such offsets that are in the development pipeline well before the carbon caps go into effect. In our view, the best way to do that is for the bill to encourage EPA to act now, even before enactment, to establish criteria for early offsets to qualify for compliance use in the program after the bill is enacted. To achieve this, the bill should clearly provide that any early offsets that meet such EPA criteria will indeed be valid for compliance. This will allow offset developers and offset buyers to have a high level of certainty regarding what offsets will qualify for compliance, and allow the early pipeline of offsets to begin to fill up almost immediately. This should significantly moderate costs in the early years of the program.

- Similarly, we would like to see improvements in the market stability reserve program. Most important is for the bill to contain clearer means to ensure that a very large number of avoided deforestation credits from national programs will be procured by the US Government and used to fill and refill the reserve. This will allow it to be large enough to provide a truly firm cap on allowance prices. We are concerned that not enough attention has yet been given to ensuring that the reserve will be large enough to effectively prevent excessively high prices, and we look forward to working with you and others to ensure that it does.

For such a complex topic as climate change, and an 820 page bill, this is a pretty short list. While there are many parts of the bill that do not affect us, and which we do not have an opinion on, I think the basic message here is that you are making a good start. While much additional work is needed, I believe most of it is focused in a relatively few areas of the bill, and that the best way to achieve success is by moving the bill forward through the Senate process. Some of the work can best be done in this committee; I'm sure much important work in addressing various regional and state-specific concerns will be done in other committees; and much will no doubt be achieved on the floor of the Senate as well. Let me assure you that, as you work to improve this landfall first draft throughout the entire Senate process, and work above all to secure the all-important 60 votes on the Senate floor, we will be pleased to act as a resource to this Committee and to each of you in this historic and critically important task.

Senator Bernard Sanders

1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Senator Sanders, we appreciate the question and it is clearly an important issue. We see greater end use efficiency as one of the key technologies for which the power sector needs the ability to invest in to achieve climate goals -- including radically increasing the efficiency of personal transportation by replacing imported oil with clean domestic electricity in America's cars and light trucks. However, as a wholesale generating company, with a retail electricity marketing subsidiary that operates only in Texas' competitive retail electricity market, we would not be among the local electric distribution companies (LDCs) that will receive an allocation under the Kerry – Boxer framework. Thus our standing and our expertise regarding precisely how the money should be spent to benefit customers may be limited. We do thoroughly support the power sector allocation framework in the bill, including as but as I testified, we believe it is insufficient in the Kerry-Boxer bill, primarily as a result of the CBO "haircut". These allocations are critical because the preserve the ability of both regulated and merchant power companies to continue to make the sort of aggressive investments in renewables and other low or no carbon technologies that NRG is currently undertaking.

One real concern with Congress mandating how the LDC allocation should be spent that we do take seriously is our understanding that this could increase the CBO "haircut" and reduce the number of allowances available for all purposes, including the support of the power sector's investment in clean technologies on both the supply and the demand side of the market. Senator Whitehouse rightly raised this issue at yesterday's hearing, and we share his concern. We believe finding ways to reduce the CBO haircut and using the savings to make the power sector allocations better reflect the power sector's share of the economy's emissions will lead to more aggressive emission reductions than will Congress mandating how the allowances LDCs receive are to be spent.

Senator James M. Inhofe

1. Do you believe that merchant companies will indefinitely need loan guarantees to support construction of new nuclear plants or do you envision the industry evolving to a point where Wall Street will become comfortable financing new plants in competitive electricity markets?

Senator Inhofe, your question goes right to what we think is one of the core issues of the nuclear renaissance. We strongly support moving from limited government support to a fully market-based approach for financing new nuclear power plants as soon as it is feasible to do so. That said, it is clear that loan guarantees are needed today, by both cost-regulated utilities and merchant power companies, for the development of the first several waves of new nuclear technology. This is in large part due to the combined factors of Wall Street being on life support, low electricity demand and low natural gas prices driving power prices to record lows, and no track record of successful permitting, construction or operation of a new nuclear power plant in this country in 3 decades. Loan guarantees not only allow financing in this context, but also help reduce costs to utility customers. In terms of how long loan guarantees may be needed, we hope that economic recovery plus the demonstration of regulatory and commercial success in developing the first wave of new nuclear power plants will allow financial markets to understand the real debt repayment risks associated with subsequent projects, and to make debt available at competitive and attractive rates.

To support aggressive, safe and low cost nuclear development, we recommend the loan guarantee program be designed to encourage the transition to full market-based financing. This would be achieved by having the initial loan guarantee program evolve to a fully – self funded, industry-based loan guarantee program. Plants that receive loan guarantees from the government would, after a large enough pool of them are operating, take on the obligation of providing the loan guarantee for additional new plants themselves. These loan guarantees would be designed to create incentives for the projects to minimize cost and risk, and to enhance operational excellence. For example, after a suitable period (e.g., construction plus 5 years), the loan recipient would face a periodic increase in interest rates to encourage private refinancing. Since most of the risk in new nuclear is during construction and early operation, this feature would focus developer attention on managing those risks efficiently and achieving a profitable operating regime that the private market should be able to refinance readily.

The industry-based funding approach would, in key regards, mirror the NEIL program for nuclear insurance, and would similarly incentivize reduced costs and best practices in terms of project development and risk management.

This approach should readily transition to full private debt market financing, if the other factors beyond the industry's control allow it to support investment in new nuclear facilities at attractive rates. And, if the other factors prevent such private financing, this approach would provide the debt insurance that is necessary for such capital intensive projects to proceed economically, without a need for ongoing or indefinite government support.

2. If loan guarantees were not available for nuclear plants, how many new plants do you think would get built within the next 10 years? Within the next 20? Would any plants get built outside of rate-regulated markets?

Without any loan guarantees, we do not believe more than a very small handful of new nuclear plants will get built, if that. This is because the very large scale of nuclear projects (which actually helps their total cost per kWh to be very competitive) also means their up-front cost is too large to finance efficiently on the balance sheet of even the largest utility companies. Without loan guarantees to allow the debt markets to participate in this financing, we do not think there can be a nuclear renaissance.

Senator Lamar Alexander

I am pleased to see that NRG has embraced the positives associated with Nuclear power. It is the most reliable zero carbon source of energy we have and today produces 70% of our carbon-free electricity. You stated in your testimony that you support the Kerry-Boxer bill but that we have no hope in getting to the 150 new nuclear units we would need to replace retired units and get nuclear generation to 40% of our electricity generated in America without a strong nuclear title.

1. **What specifically should congress do to address your comments of the need for a "regulatory process capable of handling a much larger volume of projects?"**

Senator Alexander, this is a complex goal that must maintain safety and public confidence and combine it with processing a very large number of new applications using diverse nuclear technologies in a timely manner. We have been extremely impressed with the NRC staff's diligent efforts on our application, and think the NRC is capable of expanding to meet the challenges of a broader nuclear revival. We would suggest the first step is for Congress to request a business plan from the NRC that achieves your goals, and then fund the NRC sufficiently to execute this expansion. In our view the intermediate goal should be for the NRC to be able to handle the throughput of 10 - 20 new applications per year without reducing the safety or effectiveness of the review. Notably, this task should also include identifying additional resources, changes or other activities, inside the NRC or elsewhere, that would allow new nuclear technologies, such as the HTGR, pebble-bed, and others, to efficiently proceed through the permitting process if and when they offer lower costs, enhanced safety, or superior fuel-cycle efficiencies. We believe that industry recommendations can also help Congress build on the NRC's expertise, sense of mission, and lessons learned from the combined construction and operating license application.

2. **What level of loan guarantees should there be for carbon-free electricity?**

We believe, at a minimum, $15 to $20 billion is needed to support the next handful of projects after the EPAct 2005 loan guarantees are issued. The current volume of loan guarantee is sufficient to support two to three nuclear projects. Assuming that a realistic near-term objective is set, say 25 plants in operation or construction by 2025, that number would need to be significantly larger, perhaps $60billion. But for a real renaissance and support of a variety of zero and low carbon technologies, we believe a much larger volume of loan guarantees is needed -- on the order of $100 billion. Not only will loan guarantees be essential for the nuclear renaissance, they will be very helpful for certain large scale and emerging renewable technologies, such as the concentrating solar projects we are working to develop in New Mexico and California.

3. **Should we remove the cap on the portion of loan guarantees nuclear can receive?**

The volume of loan guarantees needed for nuclear will increase with the number of new projects. We believe an artificial cap for nuclear loan guarantees could limit the amount of nuclear power, which we see as the all-critical baseload foundation for a low carbon power fleet that includes intermittent renewable energy sources and carbon capture and sequestration (CCS) technologies as well. However, instead of just removing the cap, we recommend an additional approach to meet the increasing volume. This approach would structure the nuclear loan guarantee program to evolve over time to an industry self-funding mechanism, where projects that receive loan guarantees from the government would, after a large enough pool of them are operating, take on the obligation of providing the loan guarantee themselves. This approach would, in key regards, mirror the Nuclear Electric Insurance Limited (NEIL) program for nuclear insurance, and would similarly and incentivize reduced costs best practices in terms of project development and risk management.

This approach would readily allow a transition to financing strictly through the private debt market, if the other factors beyond the industry's control allow it to support investment in new nuclear facilities. If not, it would provide the debt insurance that is necessary for such capital intensive projects to proceed economically, without a need for ongoing or indefinite government support.

4. **Should we eliminate the 10% "subsidy cost charge" that utilities must pay to receive a loan guarantee?**

We think it is fair to ask loan guarantee recipients to pay a fee based on the actual default rates and costs, especially as the track record of new nuclear projects is established. However, we believe that fee should be far below 10%, which we view as an excessively high and unjustified amount for individual projects to pay. We have analyzed historical failure rates in the nuclear industry, and believe the true subsidy cost based on those projects would be something closer to 1 to 2%.

Senator BOXER. Mr. Crane, thank you for those very important words and also your very specific recommendations. We really appreciate it.

Our second majority witnesses is Ralph—how do I say it?

Mr. IZZO. Izzo.

Senator BOXER. Izzo. And Ralph Izzo is the Chairman and Chief Executive Officer and President of Public Service Enterprise Group Incorporated.

STATEMENT OF RALPH IZZO, CHAIRMAN, PRESIDENT, AND CHIEF EXECUTIVE OFFICER, PUBLIC SERVICE ENTERPRISE GROUP

Mr. IZZO. Madam Chairman, PSEG owns and operates a large fleet of power plants. Roughly half of our power comes from nuclear generation, while the remainder is fueled equally by coal and natural gas.

We are investing over $1 billion in energy efficiency, solar generation and offshore wind. And we serve more than 2 million electric and gas customers, many of whom struggle to pay their bills.

So PSEG cannot be defined strictly as a nuclear company, strictly as a coal company, a renewable company or a regulated utility. We have all of these interests under one corporate umbrella.

As such, we have had to think hard about the challenges and tradeoffs associated with climate change. We conclude that our company, our customers and our Nation urgently need this Congress to establish a national cap and trade system. I applaud you and Senator Kerry for your bill engaging in this critical dialogue.

There are many provisions in the bill that my company supports, but some that we do not. But we choose not to let perfection be the enemy of the good. We must continue the drive to final congressional action.

First, without action, our industry is paralyzed. Those in our industry who are already subject to carbon regulation, including PSEG, are responding by making low carbon investment choices. But uncertainty about a national program slows or transition to a green economy. Those in our industry not subject to carbon regulation recognize that they soon will be.

If Congress does not act, the EPA will. The EPA has already announced its intention to regulate greenhouse gases under the Clean Air Act by March of next year.

We all know how markets respond to uncertainty. Investment is cautious, innovation is stifled, job creation is tepid. The uncertainty about carbon regulation hangs over decisions about retrofitting coal plants to reduce their emissions, pursuing new nuclear, or investing in offshore wind. It is bad for investors, it is bad for customers, and it is bad for employees.

Only Congress can give us the certainty of a sustainable national cap and trade program. This program should supersede existing regional programs to create an even and predictable playing field for investment as the bill before this committee does.

However, to ensure sustainability, we cannot overburden customers with cost increases. That is why a price collar that minimizes price volatility and limits the price of carbon while maintaining the integrity of the cap is a critical provision.

It is also vital to distribute an adequate number of carbon allowances to customers through their regulated electric utilities. Providing allowances to utilities and mandating that the savings be passed to customers is the most direct way to minimize cost increases. This was part of the allowance compromise agreed to by members of the Edison Electric Institute. This agreement recognized the need to balance protections for customers in coal heavy regions with protections for customers who are already paying higher prices for cleaner generation. I commend this committee for preserving this framework.

The second reason for moving ahead promptly on climate change is that America is losing ground to other countries. Germany and England have robust offshore wind industries. Israel and Denmark are deploying electric vehicle infrastructure. China is becoming the world's primary source for solar panels.

Putting a price on carbon is the single most important step toward making America a leader in this new energy economy. It will encourage investments in energy efficiency, in renewable energy, in energy storage, nuclear power, electric vehicles and other low carbon solutions. In short, it will create jobs. Fueled by strong State level policies, a local New Jersey company is hiring 100 workers to make inverters for solar panels for PSEG to mount on our utility poles. We need to drive this kind of job creation nationally.

The third, final and most important reason we cannot delay action on climate change is that scientists say we are quickly running out of time. The latest data sends an unmistakable message that climate change is already occurring and faster than predicted.

This issue will always be difficult. There will always be regional disputes and concerns about impacts on customers. But we must overcome these challenges sometime if we are going to confront climate change, create jobs and make America a leader in the low carbon economy.

Thank you for listening.

[The prepared statement of Mr. Izzo follows:]

WRITTEN TESTIMONY OF
RALPH IZZO
BEFORE THE UNITED STATES SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

HEARING ON CLEAN ENERGY JOBS AND AMERICAN POWER ACT

OCTOBER 28, 2009

Chairman Boxer, Ranking Member Inhofe and members of the Committee, I am pleased to be here today to testify on the Clean Energy Jobs and American Power Act.

My name is Ralph Izzo and I am Chairman, President and CEO of Public Service Enterprise Group, headquartered in Newark, New Jersey.

PSEG owns and operates a large fleet of power plants. Roughly half of our power comes from nuclear generation, while the remainder is fueled equally by coal and natural gas.

We are investing over one billion dollars in energy efficiency, solar generation, offshore wind and new nuclear power.

We serve more than two million electric and gas utility customers, many of whom struggle to pay their bills.

PSEG can't be defined strictly as a nuclear company, a coal company, a renewable company or a utility. We have all of these interests under one corporate umbrella.

With such a diverse mix of assets, we've had to carefully consider the challenges and trade-offs associated with climate change, and we arrive at the conclusion that our nation urgently needs this Congress to establish a national carbon cap-and-trade system to reduce greenhouse gas emissions.

I applaud you Chairman Boxer, along with Senator Kerry, for introducing the legislation that is now before this Committee.

There are many provisions in the bill that my company supports, and some we do not. But we choose not to let perfection be the enemy of the good. We must continue the drive toward final passage of climate legislation with a sense of urgency that matches the seriousness of the challenge in front of us.

Without action our industry is paralyzed.

Some companies are now making low-carbon investment choices, particularly those like PSEG that are already subject to carbon regulation. But uncertainty about a national program slows our transition to a green economy, complicating investment decisions about whether to retrofit coal plants to reduce emissions, pursue development of new nuclear or invest in offshore wind.

And while we delay, America is losing ground to nations around the world.

Germany and England have robust offshore wind industries. Israel and Denmark are deploying electric vehicle infrastructure. China is becoming the world's primary source for solar panels. Of the more than 50 nuclear plants currently under construction around the world, only one is in the United States.

Putting a price on carbon is the single most important step toward making America a leader in this new energy economy.

It will open the floodgates for investments in energy efficiency, renewable energy, energy storage, nuclear power, electric vehicles, and other nascent low-carbon solutions.

And it will create jobs.

For example, fueled by strong state-level policies, PSEG is hiring unemployed Newark residents to conduct energy audits in their community. And a New Jersey based company is hiring 100 workers to make solar panels for PSEG to mount on our utility poles.

We need to drive this kind of job creation nationally.

Many before me have noted that the decision facing Congress is not whether to curb greenhouse gas emissions, but whether to ensure, by enacting a cap-and-trade program, that these reductions will occur at a lower cost to consumers and our economy. Make no mistake - those not yet subject to carbon regulation know that they soon will be.

The EPA has already announced its intention to regulate greenhouse gases under the Clean Air Act by March of 2010. The immediate implication for the electric industry is that fossil-fueled power plants will be subject to New Source Review and Best Available Control Technology determinations for new power plants and major modifications of existing power plants. What constitutes Best Available Control Technology is anyone's guess right now, but by March of next year, permit writers in states will be left to figure that out. Congress can avoid this costly and cumbersome path by enacting strong cap-and-trade legislation that obviates the need for EPA to regulate greenhouse gases under the Clean Air Act.

PSEG supported the House passage of the American Clean Energy and Security Act of 2009, and we are pleased to see that several elements of that legislation are contained in the measure before this Committee today.

In particular, PSEG commends the Chairman's Mark for its recognition that climate change is a national and global threat that must be addressed at the national level rather than through separate regional efforts. While we have been an active participant and supporter of the Regional Greenhouse Gas Initiative in the Northeast, PSEG supports the moratorium on these programs contained in the bill. Ultimately, the regulatory regime for carbon must reflect the fact that greenhouse gas emissions from power plants do not represent a local public health threat as do other pollutants regulated by states under the Clean Air Act.

PSEG also strongly supports the provision in the bill allocating allowances to electricity and natural gas consumers through their state-regulated local distribution companies or LDCs. Utilities are the contact point with almost every citizen and business that will be impacted by a cap-and-trade system. Therefore, providing allowances to utilities and mandating that allowances benefit their customers is the most direct way to minimize price increases and ensure that consumers, not companies and their shareholders, realize the value of the allowances. With the LDC allocation targeted specifically for rate relief, allocating allowance to customers is the best way to prevent intolerable price increases in the early years of the program before new technologies are widely available and deployed.

The Chairman's Mark provides that all local distribution companies – whether investor-owned utilities, rural electric cooperatives, or municipally owned utilities – are allocated these allowances, with 50 percent allocated based on emissions and the other 50 percent based on electricity deliveries. This allocation formula results in an equitable distribution for all consumers. The allowances allocated based on deliveries recognize that customers in certain regions have already made investments in lower-carbon energy resources and pay higher prices as a result. At the same time, the allowances based on emissions smooth the transition for customers served by higher carbon emitting resources. This, along with a much smaller fraction of allowances set aside for merchant coal plants, make up the key elements of the EEI compromise that I worked on with my industry colleagues for two years, and I am pleased that the bill preserves this framework.

Because the power we generate for our customers accounts for 40 percent of economy-wide greenhouse gas emissions today and will account for a larger share in the future as our customers turn to electric vehicles, PSEG believes that 40 percent of the total allowances should be provided to the electric sector for a transitional period.

Another important element of the bill is the price "collar". Sustained high allowance prices or extreme price volatility could erode public support for a cap-and-trade program. On the other hand, sustained low prices will undermine investment in low- and no-carbon technologies. Companies will only make the necessary investments if they are confident that the federal program is economically and politically sustainable. Therefore, we support a price collar design which minimizes price volatility while maintaining the integrity of the emissions cap.

Lastly, PSEG is pleased that the Chairman's Mark enables state public utility commissions to dedicate a portion of the LDC allocations to help fund energy efficiency programs, but we would not support a mandatory set aside for energy efficiency from the LDC allocations. As a utility that is investing heavily in energy efficiency programs in New Jersey, but also a utility facing the fact that one in every six dollars of customers' bills is more than six months in arrears, we believe that the central objective of rate relief through the LDC allowances must be preserved.

In closing, I would emphasize my strong support for a comprehensive approach like that contained in the Chairman's Mark. We must establish a framework and a strategy that will guide our economy in deploying the lowest-cost abatement opportunities. At the same time, we believe it is important to recognize that capping carbon emissions is a powerful act that in itself will do much to drive investment in low- and zero-emitting technologies. We would recommend careful consideration of any additional programs to ensure they will actually achieve a goal beyond what cap-and-trade is inherently designed to do. In other words, additional programs beyond a carbon price signal simply may not be needed.

Madame Chairman, I thank you for the opportunity to offer my views this afternoon on the Clean Energy Jobs and American Power Act, and on the urgent need to enact climate legislation. When all is said and done, we cannot delay action on climate change.

The latest scientific data send an unmistakable message – climate change is already occurring, and faster than previously predicted.

Other scientists more qualified than me will explain to this committee the dire implications of this latest data, but I can tell you as a CEO that I have never seen our industry face a more urgent problem. We need a path forward to a low-carbon future.

This issue will always be difficult. There will always be regional disputes and concerns about impacts on customers. But we must overcome those challenges if we are going to confront climate change, create clean energy jobs and make America a leader in the low-carbon economy.

The time for action is now. I am confident that this Committee, and ultimately this Congress, will rise to the challenge.

PSEG

"Climate change is the preeminent issue of our time, with the power to transform both our company and our industry."

- Ralph Izzo, PSEG's Chairman, President and CEO

Energy Efficiency

- In November of 2008, PSE&G launched a $46 million energy efficiency program targeted to urban centers in New Jersey.
    - To date, 762 homes in Trenton and Newark have benefited from energy audits. Of them, 473 homes have received blower-door tests and air sealing.
    - 4,947 customers have received programmable thermostats
    - 79,055 CFLs have been distributed
    - 35 hospitals are receiving investment-grade energy audits
    - Program will be expanded to other Urban Enterprise Zone-designated municipalities
    - Average residential electric customer will pay about 16 cents per year, while average gas customer will pay 47 cents per year in first year of the program

- PSE&G gained approval from the BPU on July 1, 2009 to invest an additional $190 million to bring energy efficiency measures to residential customers, multi-family affordable housing units, municipal buildings and businesses such as cash-strapped hospitals.
    - Includes energy audits for homes, small businesses and hospitals and the installation of insulation, programmable thermostats and efficient lighting.
    - Expected to boost the economy by creating an estimated 689 "green" utility and contractor jobs during the next two years. About 290 of the jobs are expected to be created by hospital work.
    - Thirty-two hospitals in PSE&G territory have applied for the program. Four just recently completed investment grade audits, including University Hospital in Newark. Fourteen hospitals – including Robert Wood Johnson University Hospital in New Brunswick, St. Joseph's Regional Medical Center in Paterson and Princeton Healthcare in Princeton – are in the process of undergoing investment-grade audits. The remainder will be scheduled as audits are completed.

- **Induction lighting:** As part of its accelerated infrastructure investment approved in April by the NJ Board of Public Utilities, PSE&G will be spending $50 million to replace mercury vapor municipal street lighting with more efficient induction fluorescent lighting that will provide immediate cost savings to municipalities.
    - The utility is the first in the nation to offer the new green fixtures, which emit more light, last four times longer and cost less to operate than older models.
    - In mid-September 2009 PSE&G began installing the lights on Newark's Jersey Street and will eventually replace 96,000 older lights in 81 municipalities throughout its service area. Wayne, Secaucus, Guttenberg, Lincoln Park, Verona, Caldwell, Cedar Grove and Essex Fells have also received the installations. The project is planned to be completed over two years.
    - Vendor selection has been completed.
        - JBL Electric is performing the street light installations in the North (Metro and Palisades Division). JBL began work in the first week of September 2009 and is expected to ramp up to 200 installations per day.
        - Henkels & McCoy will be performing the installations in the South (Central and Southern Divisions) and is expected to begin in mid-October 2009.

Renewable Energy

- **Solar 4 All**. PSE&G received approval on July 29, 2009 from the New Jersey Board of Public Utilities to invest $515 million in 80 megawatts of solar projects in the next three years (through 2013), doubling the state's solar capacity and creating green jobs. PSE&G has a $190M contract with Petra Solar, which will provide the pole attached solar units, through 2010.
  - The program will install grid-connected solar systems on NJ schools, municipal buildings, low income housing complexes, non-profit owned facilities, brownfield sites, PSE&G facilities and on 200,000 utility poles in its service territory.
  - The initiative will expand New Jersey's solar infrastructure and will satisfy nearly 7 percent of the state's renewable portfolio standards requirements through 2020. The 80 megawatts of solar capacity will eliminate 1.7 million tons of CO_2 emissions, which is the equivalent of removing nearly 310,000 cars from the road for one year.
  - The impact on a typical residential customer is forecasted to be 10 cents per month in the first full year of the program and increases up to 35 cents per month in 2013.
  - **PSE&G Owned Sites:** Program has received 53 proposals for five sites, bid evaluations are under way.
  - **Neighborhood Solar (Pole-Attached):** 365 panels were delivered, 13,000 pole inspections completed, 75 panels installed in Woodbridge/Edison by PSE&G crews.

- **Solar Loans**. PSE&G is offering $105 million in loans to help expedite and finance the installation of 30 MW of solar power on homes, businesses and municipal buildings throughout its electric service area. The funding provides stable, secure capital and it is spurring investment in solar energy.
  - 99 customers have a loan commitment -- $48.2 million, 13.0 megawatts of solar capacity
  - 14 loans have closed so far -- $20.7 million, 5.7 megawatts of solar capacity
  - Customers include: Hartz Mountain Convention Center (Secaucus), American Industrial Supply (Perth Amboy), Halls Warehouse Corp. (South Plainfield), Cox Auto Trader, LLC – solar car port (Bordentown), and Continental Trading and Hardware (Newark).

- **PSEG Solar Source**
  - PSEG formed a wholly-owned subsidiary, PSEG Solar Source LLC, to develop, construct, own and operate large-scale solar facilities outside of PSE&G's service territory.
  - On September 23, 2009, PSEG Solar Source LLC completed the acquisition of two utility-scale solar projects from juwi solar Inc. to be located in Florida and Ohio. Solar Source also announced that it has developed a third solar project located in New Jersey (capacity totaling close to 30 megawatts). Under an agreement, juwi solar Inc. will provide the engineering, procurement, construction, and initial operation and maintenance services for the projects, which will be owned by PSEG Solar Source. The three projects are:
  - **The Mars Solar Garden:** a 2.2 MW direct current (DC) facility located on 18 acres adjacent to Mars Snackfood's U.S. headquarters in western New Jersey.
      - Targeted for completion in 2009.
      - Mars Snackfood has contracted for the output of the system.
    - **Florida:** A 15.0 MW DC solar farm on 100 acres in Jacksonville, Florida.
      - To begin construction in 2009 and to begin commercial operation in the summer of 2010.
      - JEA, a Jacksonville municipal utility, has contracted for the output of the system and the renewable energy credits.
    - **Ohio:** A 12.0 MW DC solar farm on 80 acres in Wyandot, Ohio.
      - To begin construction by the end of 2009 and to begin commercial operation in 2010.
      - AEP Ohio has contracted for the output of the system and renewable energy credits.
    - All three projects utilize thin film panels provided by First Solar and will be ground-mounted. The projects together will include 380,000 solar panels and represent an approximately $100 million investment by PSEG Solar Source.

- **Offshore wind.** PSEG Global has teamed with Deepwater Wind to form a joint venture called Garden State Offshore Energy, which is working to develop a 350-megawatt wind farm off the southern coast of New Jersey.

Clean, Central Station Power

- On August 18, 2009, PSEG Nuclear submitted applications to the U.S. Nuclear Regulatory Commission (NRC) to extend the operating licenses of its Salem and Hope Creek generating stations by 20 years. The company continues to explore the possibility of building an additional nuclear plant to meet the demand for clean energy and is considering filing an early site permit application in spring 2010.
    - The NRC is expected to spend 22 to 30 months reviewing PSEG Nuclear's applications before making a decision. The public will have opportunities to participate in this process.

Advanced Energy Storage

- PSEG Global is part of a joint venture called Energy Storage & Power (ES&P), which is promoting the next generation of compressed air energy storage (CAES). This technology has the power to vastly improve dispatch and the economics of renewable energy. Several third parties have submitted proposals to DOE for stimulus funding for CAES projects using ES&P technology.

Walking the Walk

- **Energy Efficient Electric Delivery Equipment.** PSE&G is investing in more efficient primary and secondary wires for new overhead installations, installing more energy efficient transformers atop utility poles when new or replacement units are needed, and expediting the replacement of aging transformer banks with state-of-the-art units in some of its electrical substations.
    - PSE&G installed approximately 5,500 higher efficiency pole-top transformers in 2008 at a cost of $10 million.
    - PSEG spent $4.6 million in 2008 on the replacement of 16 pairs of aging, high loss 26-4kV, 4 MVA transformers with 16 new 26-4kV, 9 MVA low loss transformers.
        - In addition to cutting operating line losses by over 50 percent (projected savings of over 3 million kWh per year for the total of 16 replacements), this commitment will enhance reliability.
        - All of the 16 transformers have been purchased. One has been installed so far in 2009. Installations are expected to be completed over the next 18-24 months.

- **Greening Our Own Facilities.**
    - PSEG has completed energy audits of many of its own facilities, identifying ways to reduce electric usage. Reforms under way include converting existing electric boilers to gas-fired boilers, upgrading to more energy-efficiency lighting and installing occupancy sensors.
        - Completed energy audits at 16 facilities
        - Established energy efficiency tracking measures for gas and electric energy use at 23 PSEG locations
        - Educated employees about energy efficiency and reduced water use in the workplace and home through various programs, including a lecture series
        - Continued work on Leadership in Energy and Environmental Design (LEED) commercial interiors project at the administrative office at our Linden Generating Station.
        - Initiated operation of a 75 KW solar array system on the roof of the Energy and Environmental Resource Center (EERC) in Salem.
        - Completed engineering analysis of our Hadley Road facility in Somerset and began the implementation of HVAC and lighting energy conservation measures
        - Initiated an energy conservation effort at our Lawrenceville Electric HQ implementing energy conservation measures resulting from an energy audit completed at the facility.
        - Began outreach program at our Customer Operations facilities to reduce energy consumption by employees by monitoring energy use and elevating awareness of energy use reduction.
        - Completed the installation of a 2.2KW wind turbine at our Energy and Environmental Resource Center (EERC) in Salem.
        - Completed a Green Facilities Master Plan identifying PSEG's Energy Efficiency Mission, Vision and Objectives and its linkage to sustainability and carbon reduction.

        - Achieved a Leadership in Energy and Environmental Design (LEED) Commercial Interior Silver Certification for our improvements made to the office complex at the Energy and Environmental Resource Center (EERC) in Salem.
        - Initiated the development of Energy Profiles for 3 facilities identifying energy use, energy use benchmarks, and operational and behavioral facility modifications to achieve energy use reductions and accompanying carbon reduction.
    - In 2009, PSE&G received the Corporate Green Commitment Award for a Major Corporation from the U.S. Green Buildings Council New Jersey Chapter for our promotion of energy efficiency programs and support of sustainable green building practices.

- **Greening Our Fleet.** During the next decade, PSE&G will invest in hybrid cars and light trucks, hybrid bucket truck prototypes, electric-drives and alternative fuels in an effort to reduce harmful emissions that contribute to global warming.
    - 29 hybrid cars have been purchased
    - 443 hybrid Sport Utility Vehicles have been purchased
    - 2 hybrid bucket trucks are in use
    - 235 electric drive trucks are in use
    - 2,805,373 gallons of biodiesel fuel used
    - 2 Mini E Coopers
        - On June 18, 2009 PSE&G leased two Mini-E electric vehicles as part of BMW's electric vehicle 1-year test program. The cars will be used for internal testing and data collection. PSE&G will install a wireless meter on the charging circuit at several customer locations to track electric kilowatt hours, kilowatt demand and time-of-use data for the vehicle.
        - About 20 residential customers and several municipalities in our service territory -- including Newark -- also are participating in this pilot program.

- **Greening our Operations.** PSE&G has recently modified its business practices to significantly reduce its use of mobile generators that are used to maintain reliability. As a result, we will reduce our consumption of diesel fuel, save money, and cut emissions of carbon dioxide and particulate matter.

Investing in reliability and NJ jobs

- **Capital infrastructure stimulus.** During the next two years, PSE&G will invest $694 million in accelerated electric and gas infrastructure projects – creating 900 new utility and contractor positions while ensuring that customers continue to receive safe, highly reliable electric and gas service.
  - $421 million in electric system improvements, including $50 million to replace 96,000 street lights with more efficient induction fluorescent lights. PSE&G is the first utility in the nation to offer the new "green" fixtures, which emit more light, last longer and cost less to operate.
  - $273 million in gas system improvements, including replacement and reinforcement of aging cast iron and bare steel mains and services, and upgrading metering and regulating stations.
  - PSE&G will recover costs of the programs through an annual adjustment to electric and gas rates, which would increase the typical residential customer's bill by less than 1 percent, about $9 per year.

- **Electric**
  - 69 new Electric Distribution personnel have been added.
  - $20.2M has been spent verses the filed plan of $17.7M.
  - Approximately 37 of the expected 609 FTE jobs have been created (based on the BPU stipulated calculation method).
  - The first of two contracts for the Advanced Street Lighting project has been awarded. Work is scheduled to begin in early September. The second contract is expected to be awarded in mid-September with work to begin in October.
  - Contracts are being awarded for BUD projects projects. Some aspects are still being reviewed with the IBEW.
  - Offers are being made to approximately 25 contract employees. They will be given GIS mapping assignments to free up other engineering resources to focus on various stimulus projects. The OPEIU has been made aware of this plan.
  - Engineering and/or construction is under way on 21 of the 35 stimulus projects.

- **Gas**
  - Gas Delivery will be hiring about 90 new employees; 85 new employees are on property as of late August, with offers out to the remaining positions.
  - All 2009 stimulus work has been identified and approximately 95 percent has been engineered in the layout departments. An ongoing contractor bid schedule has been established with over 30 bids awarded as of late September.
  - Over 39 miles replacement main and over 1900 replacement services have been installed as of late September.

- **Smart Grid**
  - On August 5, 2009, PSE&G submitted an application for $76 million in federal stimulus funding through the U.S. Department of Energy's Smart Grid Investment Grant Program. The $152 million project would allow for improvement in electric reliability by modernizing the distribution system, such as upgrading 40 substations.
  - According to federal government measures, the grant and network investment would account for as many as 551 jobs, including direct PSE&G hires and contractors, as well as suppliers and services.

Senator Sanders:

Q. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Ralph Izzo Response:

A. Putting a price on carbon will create a powerful incentive for carbon reductions through energy efficiency, and PSEG believes that energy efficiency must play a central role in meeting the greenhouse gas reduction goals of the bill. PSEG will have invested over $230 million by the end of next year to deploy energy efficiency to its customers in New Jersey. Some of that money is targeted to customers in urban centers, where, due to the economy and income levels, we have seen slow adoption of energy efficient products.

We think utilities are the key to driving energy efficiency at the customer level. We have the expertise and customer relationships to deliver results on a scale few others can match. But we have to find a way to enable utilities to make delivering energy efficiency a sustainable business model. We have worked with our Board of Public Utilities in New Jersey to create a regulatory approach where the utility is compensated the same regardless of whether we invest in pipes and wires or energy efficient light bulbs on behalf of a customer. This is a win-win for the environment and the electric customers, and it will motivate utilities to make these investments. Embedded in this reform is the recognition that an individual commercial or residential customer makes a much shorter-term economic calculation when deciding whether to purchase an energy efficient product than a utility would make. Therefore, changing the investor from the individual customer to the utility can make a huge difference.

We applaud you and other members of the Committee who are committed to making sure that energy efficiency is a top national priority. At the same time, I would be concerned that a mandatory set aside from the LDC allowance pool for energy efficiency might only provide a temporary boost to energy efficiency efforts compared to structural reform in utility ratemaking at the state level, such as what I describe above. And, as I mentioned in my testimony, I am also very concerned about diluting the rate relief provided by the LDC allocation by mandating that these allowances be used for any other purpose.

Please feel free to contact me if you would like to discuss this further.

Senator BOXER. Thank you, Mr. Izzo. I found your remarks to be very important.

I am going to ask Senator Gillibrand to introduce our next witness because she actually arranged that this very important witness be heard.

Senator.

Senator GILLIBRAND. Thank you, Madam Chairwoman. I appreciate you allowing me to introduce a fellow New Yorker.

Mr. Kevin Law is not just a fellow New Yorker, but also the President and Chief Executive Officer of the Long Island Power Authority, also known as LIPA. LIPA is the second largest public utility in the United States, serving more than 1.1 million customers from Montauk to Far Rockaway.

Mr. Law also serves on a number of important organizations such as the Advanced Energy Research and Technology Center located at SUNY Stony Brook, as well as the New York State Smart Grid Consortium.

Madam Chairman, I am so happy that he could be here with us today to discuss this very important legislation and his efforts to advance energy efficiency and consumer protection programs all across Long Island.

Senator BOXER. Well, thank you so much, Senator, for all your hard work. And I just want to say that, for those who are here from New York and outside of New York, the role that the Senator from New York has played in this, putting together this bill and focusing on many of the aspects, including the way cap and trade would work and also making sure we take a look at ways to incentive clean cars, especially in her home State.

So, I am just so glad you are here today. I know how hectic you are.

Mr. Law, you got a very good introduction; please proceed.

STATEMENT OF KEVIN S. LAW, PRESIDENT AND CHIEF EXECUTIVE OFFICER, LONG ISLAND POWER AUTHORITY

Mr. LAW. Well, I appreciate that. Thank you very much, Senator Boxer and my home State Senator, Senator Gillibrand. Thank you very much for those kind words.

I will be brief. I have submitted written testimony, and I ask that be entered into the record.

Senator BOXER. Without objection.

Mr. LAW. Again, I want to thank you for the opportunity to brief you on things that are going on in New York and on Long Island. I want to thank Governor David Paterson, who has challenged LIPA and is leading the way in New York in terms of energy efficiency and renewable energy, and challenging the utilities to help address the goals of New York State.

I support your efforts for this bill. The old ways of doing things in terms of generating electricity and distributing electricity are no longer working. And they are not going to allow us to address our energy challenges and economic challenges for the future. We have a 21st century high tech world with a 20th century low tech grid. And we need to be doing things differently.

We also need partnerships. No one entity can do it alone. We need the Federal Government to play its role, we need the State government and the local governments and the utilities, because no utility can do it alone either. And so we appreciate your efforts here with this legislation.

New York, Senator, is already operating under a cap and trade system. We are part of the Regional Greenhouse Gas Initiative, which is part of 10 Northeastern and Mid-Atlantic States throughout the country that are participating under RGGI. And guess what? The sky did not fall.

[Laughter.]

Mr. LAW. The program has been operating well, and all of the utilities have been cooperating. So I share that news with you.

As for LIPA, we are doing some very exciting things that I think the rest of the country can follow. We have a Solar Pioneers Program, and we have placed over 2,000 customers with solar panels to date. We are also doing the largest solar energy project in New York State's history, a 50-megawatt project.

But here is the key, and from the testimony this morning with your colleagues. Before LIPA started that solar program, there were only two companies on Long Island who were involved with the installation and maintenance of solar panels. Today, several years later, we have over 30 companies on Long Island involved with the installation and maintenance of solar panels. It is all about jobs. And we have demonstrated that we can create jobs.

We are also exploring the country's largest offshore wind project in the country. I am doing that with Consolidated Edison, an investor-owned utility. Remember, LIPA is a public utility, we do not have shareholders, we only have rate payers. We are working on that with ConEdison and other State entities and agencies, and we know that is also something that can also create jobs. So, we are in the process of exploring that.

But one of the best programs that we have going is Efficiency Long Island. It is the largest energy efficiency program for any public utility in the country. It is a $924 million program over the next 10 years, and the goal of that program is reduce our peak demand. The goal is help our customers lower their bills and to allow LIPA to avoid having to build the next power plant.

This program is the power plant we do not have to build. That is why efficiency, we believe, is the next best resource and the cheapest resource for both our rate payers and our environment.

So, I believe this legislation can work. I have submitted testimony with parts that we like and some parts where we suggest a couple of minor tweaks. But if we are going to enter into and prepare for a clean energy economy, we need to start investing in our energy future today.

We are doing that on Long Island, we are doing that in New York State with the help of Senator Gillibrand and Senator Schumer and Governor Paterson, and we know the rest of the country could do it.

We look forward to working with you and other utilities across the country to show that this can work.

Thank you, Senator.

[The prepared statement of Mr. Law follows:]

Long Island Power Authority

Testimony Prepared for the United States Senate Committee on Environment and Public Works
Legislative Hearing on S. 1733, Clean Energy Jobs and American Power Act
October 28, 2009

Kevin S. Law
President & CEO
Long Island Power Authority

Introduction

Good afternoon Chairman Boxer, Ranking Member Inhofe, and members of the Senate Environment and Public Works Committee. My name is Kevin Law and I am the President and CEO of the Long Island Power Authority, also known as LIPA.

On behalf of Governor David A. Paterson, I thank you for giving me this opportunity to testify today and to share with you the perspective of the Long Island Power Authority and that of New York State on the Clean Energy Jobs and American Power Act.

I am happy to acknowledge and thank Senator Kirsten Gillibrand – my home state Senator – for her unwavering support and all the great work she does for New York and for our country.

S. 1733 is necessary and groundbreaking legislation that will spur the new 21st century clean energy economy, diversify our energy portfolio to move toward renewables, create green jobs, reduce greenhouse gas pollution, and wean ourselves off our dependence on foreign fossil fuel.

I support your efforts and am pleased and proud to share with you the New York and Long Island story. LIPA can provide a unique perspective from a utility, state, and region that is already operating under programs to reduce pollution and develop the clean energy economy.

LIPA is the second largest public power company in the country. We serve as the primary electric provider for 1.1 million customers and a population of nearly 3 million people in Nassau and Suffolk Counties on Long Island and in Far Rockaway in New York City. We are a municipal subdivision of the State of New York and operate as a non-profit state entity and thus we do not have any shareholders – only ratepayers.[1]

[1] LIPA is a member of the American Public Power Association and the Large Public Power Council and acknowledges some of their members do not share its views and certainly does not speak on behalf of them or any other public utility in this matter.

Climate change is the most pressing environmental issue of our time. There is no question that we need bold action at the federal level, beginning with strong cap and trade legislation. We need partnerships to address our energy challenges, as no one level of government or utility can solve these problems alone. We need the federal government to work with states, local governments, and utilities. Together, we can meet our challenges.

But the need for action at the federal level does not diminish the need for action at the state level. In New York, we have taken up the mantle of experimentation and innovation. We have transformed our state into a proving ground for the latest technological advances and policy reforms. And we are setting the national standard for what a state can do by itself and with other states to combat climate change. Consequently, we believe that S. 1733 can work for the nation because we are already doing it in New York.

Our experience in New York and at LIPA under a number of aggressive and comprehensive clean energy goals and initiatives shows that we can do this.

New York is 1 of 10 Northeastern and Mid-Atlantic states (New York, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Rhode Island, and Vermont) that are participating in Regional Greenhouse Gas Initiative (RGGI). This is the first mandatory, market-based cap and trade effort in the country to reduce greenhouse gas pollution. RGGI caps and then will reduce $CO2$ emissions from the power sector 10% by 2018.

The states distribute nearly all emission allowances through quarterly auctions rather than direct allocation and expects to invest the proceeds in areas like energy efficiency, renewable energy, and other public benefit programs. Similar to what S. 1733 is designed to do, RGGI is spurring innovation in the clean energy economy and creating green jobs. By reinvesting these proceeds back into the clean energy economy, consumers will directly benefit from reduced emissions and lower utility bills through installation of clean distributed generation and implemention of energy efficiency measures.

In January of 2009, Governor Paterson announced one of the most ambitious clean energy goals in America. By 2015, New York will meet 30 percent of its electricity needs through clean renewable energy and 15 percent by reducing its demand for energy. We call this our "45 by 15" program. We estimate that meeting our 45 by 15 goal will create 50,000 new jobs for New Yorkers. Right now 21 percent of the state's energy (4 percent on Long Island) comes from renewable energy sources. To reach this goal New York has invested to date more than $800 million in energy efficiency and renewable energy resources, and New York is on pace to reach $1 billion in these investments in the coming year.

At the end of this summer New York State released a draft energy plan for our state. This plan recognizes the benefits of investing in energy efficiency and renewable energy resources, while managing the impacts of these investments on energy consumers. It is critical that we make energy more affordable for New Yorkers, in a way that recognizes that we are moving towards a carbon-constrained economy. It is anticipated that the plan will be final in December.

Also at the end of the summer Governor Paterson issued an Executive Order setting a state goal of reducing greenhouse gas pollution by 80 percent by 2050, and directed the heads of key State agencies, including LIPA, to develop a plan for how we can reach this ambitious goal.

This climate action plan will include a plan to help safeguard our people, wildlife, natural resources and communities from the climate changes that are regrettably inevitable. And the state's climate team will also work with low income communities to ensure that the steps we take to reduce emission and to adapt to climate impacts will reflect the principles of Climate Justice.

Most recently, on October 13, 2009 Governor Paterson enacted the Green Jobs Green New York Act, a new law that authorizes, using $112 million of funds provided through RGGI, a program to create green jobs and stimulate investment in weatherization and energy efficiency improvements for residential and commercial buildings. The Act authorizes the establishment of a revolving loan and green jobs training programs to retrofit homes to conserve energy. The program will target middleclass homeowners and small businesses that will pay back the loan out of what they save on their energy bills. The job training component will focus on new entrants to the workforce and displaced workers.

LIPA Energy Efficiency and Renewable Energy Programs

LIPA has been at the forefront of combating climate change through significant investments in efficiency and renewable resources. LIPA has helped transform the regional economy, create clean energy jobs, and increase the use of solar and wind power for residences, businesses, municipalities, and schools.

This year, I launched Efficiency Long Island. At $924 million over 10 years, it is one of the most ambitious energy efficiency programs for a public utility in the country. This program adds to the $355 million investment LIPA has already made in energy efficiency and renewable projects over the last 10 years, and is a key component to our 10-year energy master plan for Long Island. It is also one of LIPA's chief components in assisting New York State's efforts to reduce electric consumption by 15% by 2015.

LIPA is one of the top ten utilities in the country for solar programs. Our Solar Pioneer Program has helped install over 2000 solar roofs on Long Island and has rebated approximately $40 million for solar panels, approximately 14 MWs. This program is about to become even more successful with the assistance of Senator Gillibrand, who has preliminarily secured $500,000 in federal funding to boost the program. We are also about to construct the largest central-distributed solar systems in the United States. 50 mega watts of solar generation will be installed on Long Island, primarily at Brookhaven National Laboratory, which is a facility operated by the Department of Energy.

While our solar programs are booming, LIPA has recently established a Backyard Wind Program for residential, business, and municipal customers, offering financial incentives and technical assistance for those seeking to harness power from the wind through the use of land-based wind turbines.

In addition, with the help of a federal appropriation from Congressman Gary Ackerman, LIPA is studying the feasibility of a regional off-shore wind farm in partnership with the investor-owned utility Consolidated Edison and other state and city agencies that would be located approximately 13 miles south of the Rockaway Peninsula in the Atlantic Ocean. This project has the potential to provide between 350-750 MW with the opportunity to expand further, potentially making it the largest off-shore wind farm in the country.

Another way LIPA is ensuring that its customers can benefit and see lower bills during this transition is by using energy in a smarter way. With the help of a federal appropriation from Congressman Steve Israel and our own capital spending, LIPA has implemented a residential and commercial customer smart meter pilot program as the first step toward full-scale deployment. A total of 200 industrial, commercial, and residential LIPA customers in two separate pilot areas are currently participating. Smart meters will allow home and business owners to monitor and reduce energy usage, which can increase reliability and encourage energy efficiency by facilitating smarter end-user technologies. And of course, LIPA has filed applications to the Department of Energy for stimulus funds for several smart grid projects.

Clean Energy Jobs and American Power Act (S. 1733)

Though the chairman's mark of the bill was just released on October 23rd, we have conducted an initial review of some of the key changes and offer the following comments. (Other New York State energy and environmental officials may likely offer more substantial comments after a more thorough analysis of the Chairman's mark is completed.)

S. 1733 has the potential to secure our energy independence, create green jobs, and build a 21st century clean energy economy for Long Island and the country while containing costs and providing workable timelines for emissions reductions.

<u>The Pollution Cut</u>

We are pleased that S.1733 will establish key interim pollution reduction targets. In particular we support the 20 percent cut in 2005 greenhouse gas pollution levels by 2020.

One lesson learned from RGGI is the importance of setting the initial cap and subsequent reductions at the proper level. In 2005 modeling for the electricity sector did not take into account that we would be in the midst of the greatest economic crisis since the Great Depression. Since New York set its cap at the highest levels it is now 10 percent above where actual emissions are. The cap in the Senate Bill will avoid making the same mistake.

<u>Moratorium on state cap and trade programs</u>

It is extremely helpful that S. 1733 allows state and regional cap and trade programs to continue if the federal auction is delayed past March 31, 2011 which will prevent a gap in the programs. We are also pleased to see a specified funding program for state renewable programs.

The states that are participating in RGGI should receive auction proceeds from the federal program at a level sufficient to continue the programs currently funded by RGGI auction proceeds. The RGGI states are funding productive clean energy programs with the proceeds from the sale of allowances. These programs have economic benefits that greatly exceed the dollars expended through creation of green jobs, reducing greenhouse gas emissions and the demand for RGGI allowances. If the RGGI states are not permitted to continue the RGGI programs, federal legislation should provide a replacement funding source from the auction of federal allowances.

We remain hopeful that S. 1733 will ultimately reflect the funding commitments made in the House American Clean Energy and Security Act (H.R. 2454).

Allowance Allocations

Any federal cap and trade program should auction allowances from the outset to: (1) establish a market price for carbon; (2) allocate allowances in a fair and equitable manner; and (3) promote returning the value of allowances to the public. RGGI has demonstrated the best method of distributing allowances is through auctions. The strategic use of allowances or allowance value can both stimulate the green jobs that are vital to every state, as well as help to provide cost-containment to those businesses and citizens who will be affected by allowance prices. The more successful we are with next-generation technology investment, renewables, energy efficiency and other programs currently being run by the states, the lower the cost of carbon for those in the market.

Auction revenue can be used in a variety of ways to promote the goals of climate legislation through the promotion of energy efficiency and clean renewable energy; implementation of energy conscious state and local transportation and land use planning; implementation efforts that reduce vehicle miles travelled (VMT) and/or greenhouse gas emissions; and the development of low carbon technologies and policies. Auction revenues should also be invested with a goal of protecting low- and moderate-income citizens.

State programs to deploy energy efficiency and renewable energy are critical to achieving emissions goals at the lowest cost and to creating green jobs, and a sustainable energy and economic future. All states should have the opportunity to implement clean energy programs funded by allowance value, but the formula for allocation among the states should be based in part on the application of performance measures intended to maximize the benefit of state greenhouse gas emissions actions. For example, more allowances or auction revenues can be made available to states that have adopted state climate plans or programs that promote energy efficiency and clean energy and include elements such as decoupling, net metering and aggressive building standards.

Though we are pleased with some of the modifications that S1733 makes with respect to the allocation of allowances in H.R. 2454, I would like to point out two areas of concern to the distribution of allowances and use of allowance value. First, the legislation provides for the free allocation of most allowances, rather than auctioning allowances and using allowance value for the public benefit. Second, by allocating a total of 35% of the allowance value to the electricity industry and directing the use of allowance value toward reducing the impact of the program on the price of electricity, the legislation interferes with the price signals that should drive the transformation to the clean energy economy. At LIPA, we believe the best way of providing lasting relief from high electricity bills is to invest in energy efficiency.

The allowance allocation to the electricity sector should clearly identify public power utilities as eligible to receive free allocations. Public power utilities generate renewable energy for customers, and provide energy efficiency services to customers throughout New York State. Public power utilities need to be clearly included in the allowance allocations provided to investor-owned utilities so that they, along with investor-owned utilities, can continue to promote clean energy and energy efficiency.

Finally, we suggest the allocation for energy efficiency and renewable energy investment be increased to 15% from 10%, rather than being reduced to 5% by 2020, as specified by S1733, especially in the face of increasing federal requirements resulting from climate change legislation. The nation will not be able to achieve the aggressive, science-based goals in the legislation without continued investment in energy efficiency, renewable energy and transportation and land use policies that reduce the nation's reliance on fossil fuels. Congress can contain costs and protect consumers by promoting investment in all cost-effective energy efficiency, which would require investments that ramp-up to about $30 billion annually or approximately 26 percent of total allowances for efficiency alone. Cost-effective investments in renewable energy would require additional funding. Accordingly, we recommend that the allocation to the states for energy efficiency and renewable energy development and deployment be increased to the 15% level and remain at that level through 2020.

Preservation of Authority

We also note that the Chairman's mark-up maintains EPA's authority to regulate greenhouse gas pollution under the Clean Air Act. The history of the Clean Air Act has demonstrated the value of a multi-faceted approach to reducing emissions of air pollutants, with various programs all serving a common goal of reducing emissions at the lowest cost. Preserving EPA's authority to regulate greenhouse gas emissions under the Clean Air Act will have the same beneficial effect.

As S. 1733 is further shaped, LIPA supports your efforts to enact comprehensive climate change and energy legislation while balancing that with the impact on consumers. At LIPA, we have been doing everything in our power to protect and provide value to our customers while pushing forward on energy independence.

If LIPA and New York can be an example, then the country can successfully join with us and other state partners to implement a cap and trade program.

In New York we have over 40 communities, many from Long Island, that have taken the State's "climate smart community pledge." The Climate Smart Communities program outlines a 10-point plan to help guide communities in the reduction of greenhouse gas emissions and their adaptation to the changing climate. Climate Smart Communities have incorporated a variety of strategies in their greening programs, including: establishing baselines for emission reduction targets in municipal facilities, fleets and operations; promoting efficient technologies through use.

Carbon Market Derivatives

While LIPA is supportive of the overarching goals of S. 1733, we are also pleased to see that it does not include language found in H.R. 2454 – The American Clean Energy and Security Act in the House relating to fuel derivatives.

Inclusion of this provision in the final bill would impose mandatory clearing of over-the-counter transactions as well as requirements to force such transactions to be moved to an exchange, which would significantly increase costs for utilities seeking to manage risks through over-the-counter products, dramatically increase transaction costs and tie up needed cash at a time when the cost of capital is high, access to capital markets is uncertain, and our industry needs to invest billions in new energy infrastructure because we have a 20th century system that needs to be brought into the 21st century world.

For LIPA, institution of this requirement would increase the amount of cash collateral we post by approximately $450 million. It would cost us $22 million per year which represents about .5% in our rates and potential bond ratings downgrades which would also increase our borrowing costs.

I urge you to refrain from adding the House language S. 1733.

Conclusion

I hope that we have provided valuable information on the great programs and policies that have been implemented in New York and Long Island, and that LIPA can serve as a model to other utilities throughout the country. I am eager to partner with the federal government to expand these great programs. Thank you for the opportunity to testify and I look forward to working with you on this legislation and other critical energy challenges facing our nation.

LIPA
Long Island Power Authority

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Kevin S. Law
President & Chief Executive Officer

October 30, 2009

U.S. Senator Bernard Sanders
Senate Committee on Environment and Public Works
410 Dirksen Senate Office Building
Washington D.C., 20510
Attention: Heather Majors

Dear Senator Sanders:

I agree that energy efficiency offers tremendous value and can result in real savings for electric customers. As I testified to on Wednesday, October 28th, the Long Island Power Authority has a $924 million, ten year program for energy efficiency. We believe this is our next best resource and an opportunity for our customers to lower their bills. In response to your question, I agree that your committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDCs under this legislation.

Sincerely,

Kevin S. Law

Follow-Up Questions for Written Submission

Senator Bernard Sanders:
"We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?"

Senator BOXER. Well thank you so much, Mr. Law. There is a very can-do New York spirit there.

Now, I want to make sure that I pronounce your name right. So is it Nathaniel Keohane?

Mr. KEOHANE. Keohane.

Senator BOXER. Oh, Keohane. See, I made you Hawaiian.

Mr. KEOHANE. Exactly. I wish I were Hawaiian sometimes.

[Laughter.]

Senator BOXER. Keohane. K E O H A N E. That is a challenge.

Mr. Keohane is the Director of Economic Policy and Analysis at the Environmental Defense Fund. I want to welcome you and point out that EDF has been such an important, pragmatic partner to all of us as we sat down with business, with labor, with environmentalists, with all of the stakeholders. You have been really a stand out, and I want to thank you.

And Mr. Keohane is another majority witness.

STATEMENT OF NATHANIEL O. KEOHANE, PH.D., DIRECTOR, ECONOMIC POLICY AND ANALYSIS, ENVIRONMENTAL DEFENSE FUND

Mr. KEOHANE. Thank you, Madam Chair, and thank you for your leadership on this critical issue. I am honored to be here today.

Congress has an unprecedented opportunity right now to put the American economy on a strong footing for the 21st century. A cap on global warming pollution will ensure that we lead the world in the next generation of clean energy technologies.

And the innovation and investment unleashed by a carbon cap will help jump start our economy today while paying rich dividends later in the form of cleaner air, enhanced energy security, and most of all a livable planet to pass on to our children and grandchildren.

Now, in the process, a carbon cap will transform the public commons into a valuable asset. That asset is a public trust, and allocating its value wisely and equitably is a crucial test of any climate bill. This is the issue I would like to focus on today.

My message is simple. Consumer protection is the bedrock principle of allowance allocation. By directing a substantial portion of allowance value to households through multiple channels, as I will explain, Congress can ensure that the program is easily affordable for American families.

As part of that package, local utilities have an important role to play in helping to protect consumers. Congress should design the legislation to guarantee that households receive the full allowance value intended for them while preserving incentives for common sense investments in energy efficiency.

So, as I said just now, the allowances created by a carbon cap represent a valuable public asset. A wise allocation of that asset should be guided by three core principles. First, invest in the transition to a growing clean energy economy. Second, preserve and strengthen American manufacturing by preventing carbon leakage. And third, protect consumers. This is the bedrock principle.

In allocating allowances, we should focus first and foremost on keeping the program affordable for American families. There is no single best way to do this, no one size fits all approach. Instead, we should use a variety of channels. Because low income households are vulnerable even to small changes in energy costs, those households should be fully protected. Because we all have a stake in solving climate change, a generous broad-based dividend to every American family must be part of the package.

And because how electricity is generated varies widely in different areas of the country, local utilities can provide a useful channel for directing allowance value to households in a way that accounts for regional variation.

Let me spend a minute on the local utilities. The Kerry-Boxer bill, like legislation passed by the House, gives a large share of allowances to local distribution companies, or LDCs, for the benefit of their rate payers, including residential rate payers or households. I will show why this approach makes sense.

But first I want to underscore that in giving allowances to LDCs, the legislation should be absolutely clear that the value must flow to consumers. Safeguards to ensure this can include clear language specifying that consumers must receive the full value of allowances, requirements that LDCs publish detailed plans before receiving any allowance value, mandatory audits to ensure that those commitments are being met, and strong enforcement provisions. All of those provisions are included in the Kerry-Boxer legislation.

At the same time, I would also say that care should be taken to ensure that the method of allocating allowance value does not dampen incentives to take advantage of cost effective, common sense ways to reduce energy use. This could be done with something as simple as a monthly check made out to each household where the size of the check was the same regardless of the amount of energy consumed.

Now, back to the rationale for having the LDC approach in the first place. Even as we look ahead to the new clean energy economy, it is only fair to take into account our starting point, that is the current patterns of electricity generation that have arisen for geographical and historical reasons. In fact, as I show in my written testimony, electricity consumption is far and away the most significant source of regional variation in household level emissions. On the other hand, once you account for differences due to electricity, there is little regional variation from other sources.

Those facts tell me three things. First, allocating allowances to LDCs makes sense as a way of smoothing out regional differences. Second, as we build a new low carbon energy infrastructure, these regional disparities will disappear, and the LDC allocation can be phased out accordingly. And third, we will need other mechanisms in addition to the LDC allocation, including dedicated auction revenue for low income households as well as a broad-based consumer dividend to every American family.

Allowance allocation is sometimes caricatured as complex. But the bottom line is easy to grasp. By investing in the transition to a clean energy economy, preserving jobs, and above all, protecting American families, we can tackle climate change, achieve real energy security and strengthen our economy.

The House legislation provided an excellent start. Now it is time for the Senate to finish the job.

Thanks for much. I look forward to your questions.

[The prepared statement of Mr. Keohane follows:]

Testimony of Nathaniel O. Keohane, Ph.D.
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Before the
Committee on Environment and Public Works
United States Senate

October 28, 2009

INTRODUCTION AND OVERVIEW

I am honored to be here today as this chamber addresses one of the most important aspects of one of the most important areas of legislation any of us will get a chance to see in our lifetimes.

Environmental Defense Fund is a leading national nonprofit organization representing more than 500,000 members. Since 1967, we have linked science, economics and law to create innovative, equitable and cost-effective solutions to society's most urgent environmental problems. We have long championed market-based approaches to environmental issues, and helped design the highly successful acid-rain program created in the Clean Air Act Amendments of 1990. As Director of Economic Policy and Analysis, I oversee EDF's economic analysis of climate change policy and help to shape our advocacy. Before coming to EDF in 2007, I was an Associate Professor of Economics at the Yale School of Management, where I taught for six years. I have published a number of peer-reviewed academic articles on a range of subjects in environmental economics, and have authored or edited books on market-based environmental policy and the economics of environmental law.

Congress has an unprecedented opportunity right now — in these next few months — to put the American economy on a strong footing for the twenty-first century. Earlier this year, the House of Representatives took a crucial first step, passing comprehensive climate and energy legislation (H.R. 2454). Now it's the Senate's turn.

The centerpiece of climate legislation will be a mandatory and declining cap on carbon. A carbon cap will harness the efforts of entrepreneurs and innovators throughout our economy — ensuring that America will lead the world in making the next generation of clean-energy technologies. And the investment unleashed by a carbon cap will help jump-start our economy today, while paying rich dividends later — in the form of cleaner air, enhanced energy security, and most of all a livable planet to pass on to our children and grandchildren.

In the process, a carbon cap will transform a portion of the public commons into a valuable asset. That asset is a public trust, and allocating its value wisely and equitably is a crucial test of any climate bill.

In my testimony today, I will offer my perspective — as an economist and public policy expert — on how that test can be met in a way that strengthens our economy. The principles are straightforward: Invest in the transition to a new, growing clean-energy economy. Prevent carbon leakage while preserving American jobs. And above all, protect consumers. After presenting these guidelines, I briefly review how allowances are allocated in the legislation proposed by Senators Kerry and Boxer (S.1733), as amended in the Chairman's Mark released last week.

The bulk of my testimony focuses on the allocation of allowance value to households. Under S.1733, households would receive allowances via three channels: (1) allowances given to local electricity and natural gas utilities for the benefit of residential ratepayers; (2) auction revenue dedicated to fully compensate low-income households for any increases in energy costs; and (3) auction revenue used to fund a broad-based consumer dividend. Through these three channels, households would receive fully 43% of the available allowance value over the lifetime of the program — adding up to hundreds of billions of dollars in present value going to American families.

This multi-pronged approach to protecting consumers makes a great deal of sense. Because low-income households are vulnerable even to small changes in energy costs, they should be fully protected. Because we all have a stake in solving climate change, a generous broad-based consumer dividend must be part of the package. And because how electricity is generated varies widely in different areas of the country, using local utilities as a channel for allocating allowance value is a natural and straightforward means of accounting for regional variations.

I close by discussing how the allocation of allowances to local distribution companies, or LDCs, can be crafted to ensure that consumers benefit. First, legislation must leave no doubt that the value of allowances given to LDCs will translate into benefits for consumers, and must back up that commitment with strong monitoring and enforcement provisions. Second, legislation should guard against undue economic gains for industrial users. Third, the LDC allocation should be distributed to consumers in a way that keeps electricity and natural gas bills low, while preserving economic incentives for energy efficiency and conservation.

PRINCIPLES TO GUIDE ALLOWANCE ALLOCATION

Here are three broad guidelines for allowance allocation.

1. Invest in the transition to a growing clean-energy economy. Allowance value can provide additional incentives to accelerate the deployment and development of new technologies, overcoming market failures that hinder the adoption of energy-efficient technologies and limit the returns to research and development. In the agricultural sector, allowance value can not only help farmers manage the transition, but can also give them a leg up in taking advantage of the tremendous economic opportunity provided by the market for offset credits. And because

some climate change is inevitable, allowance value can also be invested in adaptation — enhancing the resiliency of human and ecological communities and helping them cope with a changing climate.

2. Preserve and strengthen American manufacturing by preventing carbon leakage. Particularly in the early years of a cap-and-trade program, allowance value can help manufacturing industries make a transition to a low-carbon economy while remaining fully engaged in global markets for their products. Carefully designed policies will prevent emissions leakage to uncapped countries, safeguarding the environmental integrity of the cap while and strengthening American businesses and workers. Allowance value should be distributed in a way that preserves incentives for cost-effective abatement and avoids windfall profits.

3. Protect consumers. Consumer protection is the bedrock principle of allowance allocation. A substantial portion of the allowance value should be directed to households. Moreover, by using multiple allocation channels, Congress can achieve multiple goals: providing targeted assistance to low-income consumers; fairly reflecting geographic differences in how energy is generated, in order to protect households, farmers, and small businesses; and at the same time providing broad coverage to American families. The integrity and credibility of the program must also be preserved. Allowances allocated for the benefit of consumers must be accompanied by strong safeguards to ensure that consumers receive the value.

In sum: Consumers, jobs, and the transition to a clean-energy economy are the guideposts. These principles are consistent with the Blueprint for Legislative Action put forward by the US Climate Action Partnership, a coalition of businesses and environmental groups of which EDF is proud to be a founding member.

Auction vs. free allocation is less important than it seems

Note that I have not said anything about the fraction of the allowances that is auctioned rather than given away. That may be surprising, because there has been a good deal of concern in the media and elsewhere about the supposed drawbacks of free allocation.

Despite all the attention it has received, the split between auctioning permits and giving them away turns out to be a red herring. From an environmental point of view, the allocation of allowances doesn't have any bearing on the emissions reductions that are achieved. And from an economic point of view, the distinction between auctioning and freely allocating allowances matters much less than how the value of those allowances is distributed.

First, let's consider the environmental performance of the program. It's pretty obvious that the atmosphere doesn't care whether the allowances are auctioned off or given away. From an environmental perspective, all that matters is the cumulative emissions into the atmosphere. That's the job of the cap, which ensures that we achieve the reductions scientists tell us we need.

In fact, as I noted above, a wise allocation of allowances can even enhance the environmental outcomes achieved by the legislation — by preventing emissions leakage, driving technological innovation and deployment, jumpstarting emissions reductions on farms and forests, and helping communities adapt to climate change.

Perhaps more surprisingly, the economic performance of the program also does not hinge on whether the allowances are auctioned or freely allocated. Under a cap-and-trade program, the economic incentive to reduce pollution comes from the price of allowances — which will be determined by the cap, not by how allowances are distributed. In the jargon of economics, there is an opportunity cost associated with holding allowances, regardless of whether a firm got those allowances for free or had to buy them from the government.

Because the value of allowances is independent of how they are distributed, so is the incentive to reduce pollution. In fact, as a general rule, whether allowances are auctioned off or freely allocated will not have any impact on the cost-effectiveness of the program.*

If the auction versus allocation split doesn't matter for the environmental performance of the bill, and it doesn't affect the economic incentives, surely it matters for distribution? Wrong again. Distributional impacts depend on who gets the value of the permits — not whether they are sold at auction or not. After all, being given permits worth $1000 is no different than receiving $1000 in auction revenue.

In sum, it matters little whether the value of allowances is distributed directly (through free allocation) or in the form of auction revenue. As I will discuss below, *how* the allowance value is distributed does play an important role. But first, let me review the approach to allocation in the proposed legislation.

THE APPROACH IN THE PROPOSED LEGISLATION

One of the common criticisms of the House-passed bill, which we are sure to hear applied to the Senate legislation, is that it supposedly gives away most of the allowances for free – the implication being that they are given to "big emitters who don't need them." In fact, that conventional wisdom gets the story almost entirely backwards.

* This result is a standard tenet of economic theory, going back to Ronald Coase's seminal article in 1961. A more recent body of work in the environmental economics literature shows that using revenue from allowance auctions to reduce marginal tax rates on labor or capital can provide a boost to overall economic efficiency. However, this result hinges on the *use* of allowance value to reduce pre-existing taxes, not the mere fact that allowances are auctioned. Hence it is entirely consistent with my basic argument: what matters is how the value of allowances is distributed.

Over the life of the program, the cumulative value of available allowances under S.1733 would be distributed as follows: *

- Households: 43%

  Channeled to consumers through allocations to LDCs; an energy refund program for low-income households; and a broad-based consumer dividend.

- Small businesses: 8%

  Distributed by electricity and natural gas LDCs to commercial ratepayers.

- Public purposes: 25%

  Funding for public purposes such as worker training, technical assistance to farmers, clean energy research and development, and the protection of vulnerable ecosystems.

- Industry: 24%

  Most of this category goes to energy-intensive trade-exposed industries, to prevent carbon leakage and ensure a level playing field for U.S. businesses and workers. Other industries will receive smaller allocations to offset compliance costs. These allocations would phase out almost entirely by 2030.

When you add it all up, 76 percent of allowance value would go to households, small business, and public purposes (see Figure 1). This breakdown is very similar to that in H.R. 2454.

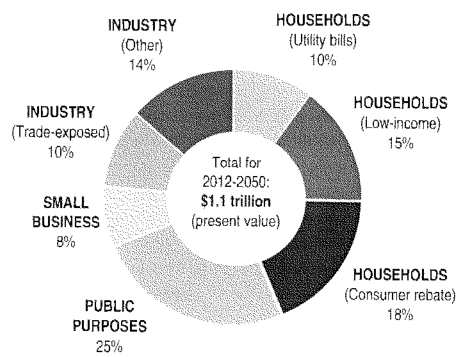


Figure 1: Allocation of available allowance value under S.1733. *Source*: Author's calculations.

* All allocation percentages refer to the percentage of available allowances, defined as the number of allowances available for distribution after subtracting off the allowances withheld for the Market Stability Reserve (§726) and directed to the Treasury for deficit reduction.

FOCUSING ON HOUSEHOLDS

The bedrock of allowance allocation is consumer protection. All of us have a common stake in sound and effective climate legislation. And while there has been a good deal of discussion about "cost containment" in climate legislation, the simplest and best way to contain costs for American families is to return a significant proportion of allowance value to them.

How S.1733 directs value to consumers

S.1733 channels allowance value directly to households in three ways. First, to address regional disparities in how electricity is generated, roughly 39 percent of available allowances in the first phase of the program (2012-2030) will go to local distribution companies (LDCs) that deliver electricity and natural gas to residences, commercial businesses, farmers, and manufacturers.

Households would receive allowances according to the residential share of the electricity and natural gas distributed. LDCs are regulated by state commissions, and the value of allowances would have to benefit energy consumers. What's more, as I describe in more detail below, the legislation includes clear and stringent provisions requiring LDCs to demonstrate how they will pass the value on to consumers before they can receive a single allowance.

Second, S.1733 sets aside 15 percent of allowances to be auctioned off, with the revenues to fund an energy refund program for low- and moderate-income households. This is crucially important, as low-income households in particular are least able to weather even small and temporary increases in energy prices. The Center for Budget and Policy Priorities, a think-tank that focuses on poverty alleviation, has estimated that a similar 15 percent allocation in the House-passed bill, in conjunction with other provisions (such as the LDC allocation), will be sufficient to <u>fully compensate</u> the poorest one-fifth of households for costs related to energy prices that may affect them.

Third, most of the allowances in the later years of the program would be returned to all households through a broad-based consumer rebate. Over the life of the program this amounts to nearly one-fifth of available allowance value — the biggest single category of allowance allocation in the legislation.

It's easy to get lost in all the percentages. But in a sense the true test of allowance allocation boils down to just one number: the estimated cost to American households.

Analysts at the Environmental Protection Agency have looked closely at the differences between S.1733 and the House-passed legislation, concluding that on balance "the differences between the bills result in relatively small differences in estimated costs and may even cancel each other out on net."* In short, the conclusions from the EPA's analysis of the House-passed legislation remain relevant. That analysis used two of the most highly respected, peer-reviewed economic

* U.S. Environmental Protection Agency, "Economic Impacts of S.1733: The Clean Energy Jobs and American Power Act of 2009," October 23, 2009, p. 2.

models available. It looked only at the costs of reducing emissions, and ignored the benefits from averting the catastrophic consequences of unchecked climate change, not to mention cleaner air and greater energy security.

Even just looking at the cost side of the ledger, EPA's analysis of the House-passed bill projected that over the entire life of the bill, the annual cost to the average household will be just $80 to $111 (in present value). That is just 22 to 30 cents a day for the average American family. The same conclusion was reached independently by the Energy Information Administration (the statistical arm of the Department of Energy) and the Congressional Budget Office. In its analysis of H.R.2454, EIA estimated the average annual household cost to be just $83, while CBO's figure for the year 2020 was $160 ($93 in present value). Each of these estimates works out to be less than the cost of a postage stamp per day per household.

The value of a multi-pronged approach

As discussed above, the proposed legislation envisions multiple channels to direct allowance value to households. That's important, because households differ along a number of dimensions (in particular geography and income), and multiple channels provide a way to address these dimensions separately.

First, allocating a portion of the allowance value to low-income consumers can address concerns about the impact of higher energy prices on those people who are least able to respond. While the overall impacts will be very slight — recall the consensus estimates of less than the cost of a postage stamp a day for the average household — even that amount can be a stretch for consumers who are already struggling to afford basic food and shelter. As noted above, setting aside 15% of allowances is sufficient (in conjunction with the LDC allocations) to make low-income households whole. In fact, an analysis by the Congressional Budget Office estimates that low-income households will see a net gain from the allocation provisions — receiving more in the way of allowance value than they will face in terms of increased energy expenditures.

Second, a broad-based consumer dividend provides a natural way to compensate consumers for increases in energy costs that do not vary by region, such as transportation fuels. Such a consumer rebate also captures the fundamental reality that the value of the carbon cap is a public asset, and one that should be used as much as possible for the common good.

Finally, giving a portion of allowances to local electric and gas utilities for the benefit of customers can address geographic disparities. This is particularly true for the electric power sector, since a price on carbon will have different impacts on different areas of the couutry, depending on the types of fuel used to generate electricity. Even as we look ahead to a new clean-energy economy it is only fair to take into account our starting point — current patterns of electricity generation that have emerged over time, for geographical and historical reasons unrelated to the challenge of solving climate change. As we build a new low-carbon energy infrastructure, these disparities will disappear, and the LDC allocation can be phased out accordingly.

I want to be careful not to exaggerate the extent of regional variation in carbon dioxide emissions. On the contrary, total household emissions vary much less across regions than is commonly assumed. As Figure 2 shows, CO_2 emissions from households in different regions are grouped around the national average, with the highest and lowest emitting regions of the country less than 15% (5 tons) above and below the national average. Moreover, the largest single source of household emissions is the indirect emissions associated with the production of non-energy-related goods and services — a category that does not vary by region.

Nonetheless, it is also the case that to extent household emissions do vary among regions, the differences are largely due to electric power generation. This conclusion — evident in the chart below — is made even clearer by Figure 3, on the next page.

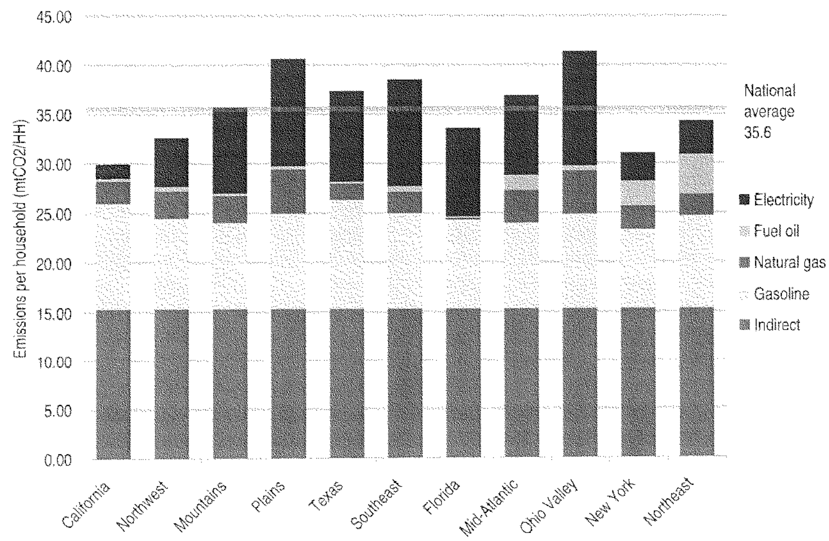


Figure 2: Household carbon dioxide emissions by region. *Source*: Author's calculations based on data in Dallas Burtraw, Richard Sweeney, and Margaret Walls, "The Incidence of U.S. Climate Policy," RFF Discussion Paper 09-17-REV (June 2009).

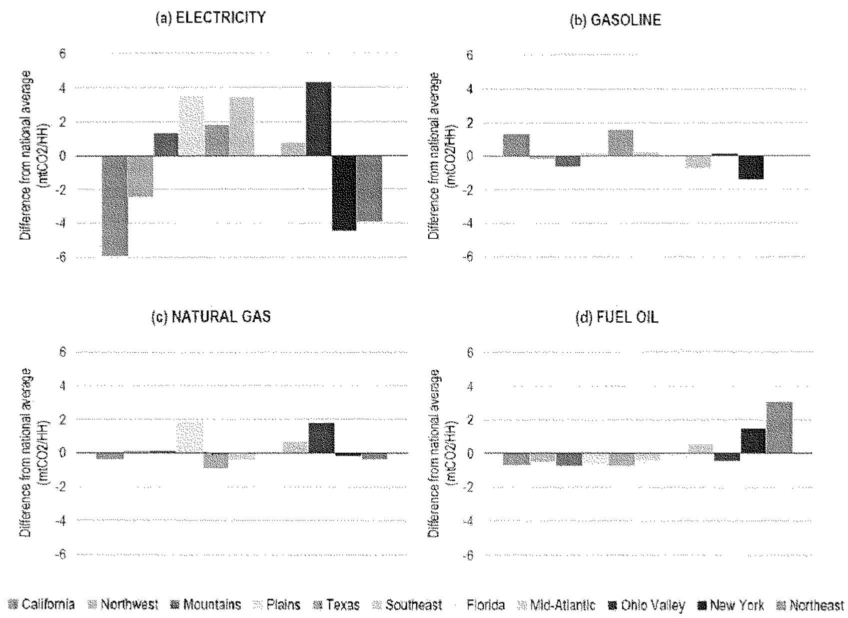


Figure 3: Regional variation in household direct emissions by region and fuel type. Bars represent deviations from national averages; the vertical scale is constant across the four graphs. *Source*: Author's calculations based on data in Dallas Burtraw, Richard Sweeney, and Margaret Walls, "The Incidence of U.S. Climate Policy," RFF Discussion Paper 09-17-REV (June 2009).

Each panel in Figure 3 presents regional variation in household CO_2 emissions from a single fuel type, measured as a deviation from the national average. The vertical scale is constant across the four panels for ease of comparison. As the figure shows, electricity is by far the most significant source of regional variation in emissions.

Taken together, Figures 2 and 3 offer powerful support for a multi-pronged approach to allocating allowances to households. On the one hand, Figure 3 shows that there is significant regional variation in emissions from electric power generation – underscoring the importance of channeling some household allowance value via local utilities. On the other hand, both charts suggest that once electricity generation is accounted for, there is little remaining variation among regions – suggesting that a broad-based dividend is appropriate, in combination with a targeted allocation for low-income households.

KEY DESIGN ISSUES IN THE ALLOCATION OF ALLOWANCES TO LDCS

Three design issues are crucial in channeling allowance value to households via local utilities. First, Congress must ensure that consumers receive the value of those allowances. Second, Congress should take steps to prevent industrial users from receiving undue economic gains. Third, Congress should do its utmost to direct local utilities (and the state commissions that regulate them) to distribute the allowance value in a way that cushions households against higher electricity costs while preserving incentives for energy conservation and greater energy efficiency.

Ensuring that consumers receive the value of allowances

The rationale I have laid out for giving allowances to local utilities depends crucially on the full value of those allowances being passed on to consumers in the form of lower utility bills. That cannot be left to chance: it must be guaranteed in the legislation.

The language in S.1733 addresses this issue in several ways. In particular, the legislation:

- requires that local electric distribution companies "shall pass through to residential retail ratepayers as a class their ratable share ... of the value of emission allowances that reduce electricity cost impacts on such ratepayers" (§772(b)(5)(D) in the Clean Air Act as amended by Division B, Title I, Subtitle A, section 101 of S.1733);

- directs the EPA Administrator to prescribe guidelines for LDC allocation that include requirements for LDCs to pass on the full value of allowances, along with measurement, verification, and reporting requirements (§772(b)(5)(E));

- makes the allowance allocation to an LDC contingent upon the completion and periodic updating, by the state commission or other regulatory body, of a public rulemaking process incorporating these requirements, along with a published report (§772(b)(6));

- requires LDCs to submit plans for the use of allowance value along with annual reports detailing the actual disposition of allowances (§772(b)(7));

- mandates annual auditing by the EPA Administrator to ensure that allowance value is used for the benefit of ratepayers, along with periodic (triyearly) in-depth reports by the General Accounting Office and the Administrator evaluating the use of allowance value and the effectiveness of the program in containing costs (§772(b)(8));

- specifies that a violation of any of these requirements is a violation of the Act and is subject to enforcement (§772(b)(9)).

Similar language is included in §773 of the bill with regard to natural gas local distribution companies.

Preventing double-counting and undue economic gains for industrial users

My testimony has focused on the allocation of allowance value to households. Of course, some fraction of allowance value may be allocated directly to firms in the industrial sector. One prominent example in the proposed legislation is the output-based rebates for trade-exposed industries, designed to prevent carbon leakage and level the playing field for American workers and manufacturers. Another example pertains to the LDC allocations: industrial ratepayers would receive their ratable share of the allowance value under S.1733 (as is also the case under H.R. 2454).

Allocating allowance value to industrial sources can play an important role in smoothing and accelerating the transition to a clean-energy economy. Nonetheless, the ultimate purpose of allowance allocation should be to protect American families, both by cushioning consumers against increases in the cost of goods and services and by preserving American jobs. Any allocation to industrial entities should take that ultimate purpose into account, and ensure that shareholders do not capture undue economic gains.

Two concrete approaches can help in these tasks. First, since the number of allowances is limited, it makes sense to ensure that allocations to industry are tailored as closely as possible to the underlying need. In the case of LDC allocations, a potential concern is emissions due to the electricity that is consumed by energy-intensive trade-exposed (EITE) industries. If allowances are given to LDCs for the electricity they distribute *and* to manufacturers for the electricity they consume, the potential for double-counting arises. While S.1733 includes language designed to prevent double-counting, the most straightforward solution would be to include both direct and indirect emissions as part of the EITE allocation — while focusing the LDC allocation on households and small businesses. Congress should also use the best available data on emissions and manufacturing output in determining the appropriate EITE allocation — and should direct the EPA Administrator to do the same when implementing it.

Second, in providing allowance value to firms (including via LDCs), Congress should recognize the wide disparity in the ability of firms in different sectors to pass along their costs to consumers. The relevant task here is to determine what economists call the "cost pass-through rate," defined as the fraction of an increase in input costs that a firm can pass on to its customers. When cost pass-through rates are high, there is less need (or justification) for giving allowances to firms. Instead, in such instances the value of allowances should be given to the end consumers, who will ultimately bear their cost.

In turn, the cost pass-through rate depends on standard economic measures of price sensitivity — what economists call the elasticity of demand and supply. When demand is less elastic than supply — that is, when consumers respond less readily to price changes than producers do — the cost pass-through rate will be high. This will be the case, for example, when few substitutes are available for a product. The degree of competition among producers also plays a role.

Evidence on cost pass-through rates varies, but studies have generally found them to be near 100% for many consumer goods. (The Congressional Budget Office, for example, typically assumes full cost pass-through in its analyses of legislation.) Of course, for particular industries the cost pass-through rate may be substantially lower.

It is important to note that the degree of pass-through applies to changes in costs at the margin – that is, costs that depend on how much a firm produces. An important implication is that even if firms receive "lump sum" compensation (e.g., a check for their share of allowance value that is not tied to electricity consumption), they will still tend to pass on the cost of allowances to their own customers – creating the potential for undue economic gains, or "windfall profits."

To address these concerns, Congress could follow the same approach as in the provisions of S.1733 dealing with allocations to merchant coal generators – namely, requiring a study to be carried out determining the allocation has resulted in windfall profits, along with a requirement that allocations be adjusted if necessary (cf. §772(c)(5)).

Preserving incentives for investments in energy efficiency

Care must also be taken to ensure that the method of allocating allowances does not dampen the incentives to take advantage of cost-effective, common-sense ways to reduce energy use. The LDC allocation should be passed along to consumers in a way that preserves the price signal from the carbon cap, while compensating them directly for any increase in price.

The most straightforward way to achieve this would be to divide up the residential share of allowances equally among households, and send each household a check for that amount every month or quarter.*

Of course, this is not the only possible approach. Increased energy efficiency also reduces household expenditures, by lowering consumption. Utilities could be given the latitude to invest allowance value in demand-side energy efficiency programs — provided that they can demonstrate that those programs are cost-effective and result in real reductions in household bills.

S.1733 prohibits distribution of allowance value "based solely on the quantity of electricity delivered" to a given ratepayer and expresses a preference "to the maximum practicable" for fixed credits or rebates (§772(b)(5)(C)). The importance of the price signal is also enshrined in the

* In the case of commercial and particularly industrial users, who vary greatly in size, the appropriate amount might vary among categories of users, or might be tied to the average energy use of similar customers. But the principle remains the same: the amount of the rebate to any individual customer should not depend on the actual amount of energy consumed. This is particular important in the case of industrial users, who generally face much greater opportunities for cost-effective energy efficiency and therefore have more "elastic" (price-sensitive) demand for energy. On the other hand, as already pointed out, lump-sum compensation to industrial users can result in windfall gains. Congress should pay careful attention to these issues in order to preserve the incentives for energy efficiency while avoiding imparting undue economic gains to industry.

annual auditing provision, which directs the EPA Administrator to "assess the degree to which electric local distribution companies have maintained a marginal price signal while protecting consumers on total cost using the value of emissions allowances" (§772(b)(8)(A)). Even so, greater guidance may be needed to further clarify the meaning of "consumer benefit," to preserve the price signal while compensating consumers, and to express a preference for the straightforward and simple approach of sending households a check.

CONCLUSION

Allowance allocation is sometimes caricatured as complex, but the basic principles are easy to grasp. Invest in a new, growing, clean-energy economy. Prevent carbon leakage while preserving American jobs. And above all, protect consumers, by ensuring that a significant portion of allowance value is returned to households. Focusing on these principles can produce lasting legislation that tackles climate change, provides real energy security, and strengthens the American economy. The House legislation provides an excellent start. Now it's time to finish the job.

Environment and Public Works Committee Hearing
October 28, 2009
Follow-Up Questions for Written Submission

Responses of Dr. Nathaniel Keohane, Director of Economic Policy and Analysis, Environmental Defense Fund

Question from Senator Bernard Sanders:

We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Vermont is indeed doing a great deal to implement successful energy efficiency programs which both save energy and reduce costs. In fact, the American Council for an Energy Efficient Economy (ACEEE) recently ranked Vermont sixth in its list of leading U.S. states doing the most to implement energy efficiency in its *2009 State Energy Efficiency Scorecard* report.[1] Energy efficiency can be an invaluable resource as we strive to achieve our emissions reduction targets and reduce costs for consumers.

As I discussed in both my written and oral testimony, the bedrock principle in allocating allowance value is consumer protection. This is also the main rationale for the allowance allocation to local distribution companies (LDCs) that is included in the Kerry-Boxer bill. This allocation should be passed along to consumers in a way that preserves the price signal from the carbon cap, while compensating them directly for any increase in price. The most straightforward way to achieve this would be to divide up the residential share of allowances equally among households, and send each household a check for that amount every month or quarter.

However, another potential approach, as you suggest, would be to use a share of the LDC allocation for investment in energy efficiency programs—for example, programs to fund household rebates for purchases of energy-efficient appliances, or to provide subsidies for weatherproofing. Well-designed programs can lower household bills by reducing energy consumption, without affecting the services that energy provides (such as heating and cooling).

If Congress chooses to follow this approach, two issues should be kept in mind. First, the benefits of greater energy efficiency vary across households according to income, home ownership status, and dwelling type. Low-income families, for example, are likely to

[1] ACEEE's *2009 State Energy Efficiency Scorecard* report can be found here: http://www.aceee.org/pubs/e097.htm

benefit less from energy-efficiency measures while having a relatively high value for direct compensation (in the form of a rebate check). Renters may not own their appliances or be able to carry out weatherproofing. And apartment dwellers, like myself, may not have the opportunity to carry out exterior weatherproofing or to install more energy-efficient heating and cooling systems.

Second, if allowance value is to be used to fund energy efficiency programs, those programs must be demonstrated to reduce household utility bills by an amount equivalent to (or greater that) the allowance value dedicated to them.

Taken together, these two issues—the variation among households, and the importance of demonstrating cost savings to consumers—suggest that Congress should avoid mandating that any particular percentage of allowance value be spent on energy efficiency. Instead, Congress should give local utilities (and the public utility commissions that oversee them) the latitude to decide how whether to return the allowance value directly to consumers, or to use that value to fund energy efficiency programs that meet the criteria above.

Question from Senator James M. Inhofe:

If consumers receive subsidies to offset higher electricity prices that necessarily will arise from cap-and-trade legislation, would that undercut the point of cap-and-trade, which is to force change from fossil fuels to low- or no-carbon fuels?

The short answer is "no." As I explain in my testimony, and as numerous other economists have argued in other forums, the allocation to consumers can be designed to protect them against higher energy costs while preserving the marginal price signal that will reward common-sense investments in energy efficiency and conservation.[2]

At a broader level, this question gets right to the heart of why cap-and-trade is the most effective form of climate policy—from both an economic and environmental standpoint. The cap—the mandated decreasing allowable emissions over the life of the program—guarantees the environmental benefits, regardless of how allowance value is allocated. The price signal generated by the cap-and-trade program is what will drive innovation and investment in low and/or zero carbon technologies.

In addition to ensuring that we achieve this environmental benefit, a cap-and-trade program allows for the flexibility to distribute allowance value in a way that protects consumers and provides compensation for increased costs due to the program. In this way, we can maintain consumer purchasing power, ensuring that our economy will

[2] See, for example, the arguments made by Professor Robert N. Stavins of Harvard University in his blog post of October 22, available at http://belfercenter.ksg.harvard.edu/analysis/stavins; and the testimony of Professor Gilbert Metcalf of Tufts University, presented to the Senate Committee on Energy and Natural Resources, October 21, 2009.

continue to grow robustly, while simultaneously achieving our emission reduction targets.

If we look at the electricity sector specifically, the allocation provision included in both the House bill and the Boxer-Kerry bill distributes allowance value to local distribution companies (LDCs) which are required to pass on this value to their consumers. Although the cap ensures the emission reductions outlined in the bill, it remains important to preserve the price signal to consumers in order to encourage changes in behavior such as increased energy efficiency and conservation. As I outlined in my written testimony, care must be taken to ensure that the method of allocating allowances does not dampen the incentives to take advantage of cost-effective, common-sense ways to reduce energy use. The LDC allocation should be passed along to consumers in a way that preserves the price signal from the carbon cap, while compensating them directly for any increase in price. The most straightforward way to achieve this would be to divide up the residential share of allowances equally among households, and send each household a check for that amount every month or quarter. Other approaches might include giving utilities the latitude to invest allowance value in demand-side energy efficiency programs, provided that they can demonstrate that those programs are cost-effective and result in real reductions in household bills.

Again, cap-and-trade allows for the flexibility to simultaneously provide incentives through the cap to drive new clean energy technologies which will enable us to achieve our emission reduction targets, while also providing the means to protect consumers through the allocation of allowance value.

Senator BOXER. Thank you very much.

OK, our next majority witness, and our last majority witness on this panel, Joel Bluestein, President, Energy and Environmental Analysis Incorporated, ICF International.

Welcome, sir.

STATEMENT OF JOEL BLUESTEIN, SENIOR VICE PRESIDENT, ICF INTERNATIONAL

Mr. BLUESTEIN. Thank you very much.

Good afternoon. My name is Joel Bluestein. I am a Senior Vice President at ICF International.

We became part of ICF International almost 3 years ago. ICF is a consulting firm headquartered in Fairfax, Virginia, that provides objective technical analysis to public and private sector clients including U.S. Government agencies, but does not take advocacy positions on these topics.

I am happy to be here today to discuss the potential role of natural gas in addressing greenhouse gas emissions.

Many people expect that natural gas will play an important role in achieving greenhouse gas reduction. This is not surprising since natural gas has the lowest carbon content of all fossil fuels. It can be used in very efficient technologies, and it can be used effectively in power generation, transportation and direct in-use applications.

At the same time, there is concern for some that gas could play too large a role, that a massive dash to gas will occur in the electric power sector and that North American gas supply is too limited to support this increased gas consumption.

My two messages are, one, the recoverable U.S. natural gas resource is understood today to be much larger than ever before, and two, a variety of projections show that natural gas can play a significant role as part of a greenhouse gas mitigation strategy without causing economic upheaval and hardship.

As a point of reference for the estimates of the natural gas resource, U.S. consumption of natural gas has been in the range of 22 trillion to 23 trillion cubic feet per year for the last 12 to 15 years. The most recent estimate of the U.S. natural gas resource is this year's report of the Potential Gas Committee, a nonprofit independently governed entity associated with the Colorado School of Mines.

The PGC's most recent report, the 2008 assessment released in June 2009, estimates that the total U.S. natural gas resource base, at the end of 2008, was 2,074 trillion cubic feet, more than 36 percent higher than the 2006 estimate. This total reflects the highest level in the committee's 44-year history and represents about 90 years of supply at current consumption levels.

The big change in this new assessment is a greatly increased evaluation of the shale gas resource largely due to the development and application of new drilling and production techniques. These advances have allowed shale gas to evolve from a small component of the gas resource to the major gas component. The Barnett shale formation near, and actually underneath, Fort Worth, Texas, by itself currently accounts for approximately 10 percent of U.S. natural gas production.

The increased supply from these resources has fundamentally changed the supply demand balance for natural gas in North America.

Turning to the role of natural gas in greenhouse gas reduction, interestingly the base case modeling performed by the U.S. EPA and EIA, of the Waxman-Markey bill, and by extension, of the Kerry-Boxer bill, does not show a dash to gas. These projections show gas use flat or slightly declining even in the power sector.

The key drivers of these results are very low energy demand growth, very high reliance on offsets, and higher reliance on new low emitting technologies such as renewables, nuclear, and coal with carbon capture and storage.

Under these conditions, there will be limited demand for gas. However, most analysts expect that the supply of offsets will be significantly less than the maximum allowed under the bills and that some of the technologies may be slow to reach wide application.

The EIA has run a scenario with no international offsets and no new nuclear or CCS technology which results in a 15 percent increase in gas consumption in 2020 and a 25 percent increase in 2030. Even with this significant increase in natural gas consumption, the well head price of gas increases by $1 per million BTU in 2020, and actually does not increase from the base case in 2030.

So, even a significant increase in gas consumption does not result in a major increase in the long-term price of gas. Moreover, these cases do not include the most recent data on expanded natural gas supply, which could reduce the price impacts.

Finally, I want to note that one of the important changes in the Senate bill relative to the House bill is the delay in direct regulation of fugitive methane emissions. This allows the generation of offsets from methane sources through 2020, which would otherwise be precluded.

Since the use of offsets is one of the most important cost control measures in the bill, the ability to increase the supply of offsets could be important to ameliorate allowance prices.

Overall, we expect that compliance with greenhouse gas legislation will require the use of a diverse mix of clean technologies including gas, coal with CCS, renewables, nuclear and energy efficiency. We do not expect any one technology to dominate.

That said, we expect that several of these options are unlikely to be widely available until at least 2020. Thus, we do see an increased role for natural gas at least through that time, especially if the availability of offsets is limited and the economy is revitalized.

Fortunately, the new drilling and production techniques have expanded our natural gas supply options and should allow us the flexibility to use gas cost effectively as one of the options for greenhouse gas reduction.

Thank you for the opportunity to testify, and I look forward to your questions.

[The prepared statement of Mr. Bluestein follows:]

Committee on Environment and Public Works
United States Senate
Legislative Hearing on S. 1733, Clean Energy Jobs and American Power Act.
October 28, 2009

Statement of
Joel Bluestein
Senior Vice President
ICF International

Good afternoon Madam Chairman and members of the Committee. My name is Joel Bluestein and I am a Senior Vice President at ICF International. ICF is a consulting firm located in Fairfax, Virginia that has been in business providing energy and environmental consulting services for 40 years. ICF provides objective technical analysis to public and private sector clients, including agencies of the U.S. Government but does not take advocacy positions on these topics. Thank you for the opportunity to appear before the Committee to discuss the role of natural gas in addressing greenhouse gas reductions.

Many people expect that natural gas will play an important role in achievement of GHG reduction targets. This is not surprising since natural gas:

- Has the lowest carbon content of fossil fuels – a little more than half that of coal
- Can be used in very efficient technologies
- Can be used effectively in power generation, transportation and direct end use applications

At the same time, there is concern for some that gas could play too large a role; that a massive "dash to gas" will occur in the electric power sector and that North American gas supply is limited to the extent that increased gas consumption could cause shortness of supply and or much higher gas prices.

Natural Gas Supply

The good news in this respect is that recent developments in gas drilling and production have greatly increased estimates of the U.S. gas resource in ways that can address these concerns. The view of these resources has changed rapidly in recent years. The focus of these changes is in the estimated volumes of undeveloped recoverable gas resources. These are the estimated volumes of gas that are not yet classified as proved but that are expected to be recoverable or producible in the future. The volume of such undeveloped resources is estimated using a range of assessment methodologies, depending upon the nature of the resource and its stage of development.

Several organizations in the U.S. assess the volume of technically recoverable resources from tight gas, shale gas, and coalbed methane, as well as from future conventional fields. The USGS is the principal organization for assessing onshore gas and oil resources. It assesses oil and gas resources at the formation or play level. The USGS maintains a website with the latest assessments for each geological basin[1]. The U.S. Energy Information Administration (EIA) and National Petroleum Council (NPC) also publish assessments of unconventional natural gas. The EIA publishes the Annual Energy Outlook[2], which includes assumptions about natural gas supply and resources. The NPC published its most recent North American natural gas study in 2003[3], which included extensive documentation about resources and activity trends in the U.S.

[1] USGS National Oil and Gas Assessment; http://energy.cr.usgs.gov/oilgas/noga/
[2] U.S. Energy Information Administration, *Annual Energy Outlook*; http://www.eia.doe.gov/oiaf/aeo/
[3] National Petroleum Council North American Gas Study, 2003; http://www.npc.org/

and Canada. Another prominent U.S. assessment group is the Potential Gas Committee, which publishes a detailed assessment every two years (discussed below). ICF also prepared a study in 2008 for the INGAA Foundation on the status of unconventional gas resources[4].

The most recent assessment by the EIA is for 2007, showing the total U.S. natural gas resource base (proven reserves plus unproven resources) at 1,771 trillion cubic feet (Tcf) of technically recoverable natural gas, including 238 Tcf of proven reserves[5].

The rapid change in the understanding of the U.S. natural gas resource is most recently depicted in this year's report of the Potential Gas Committee. The Potential Gas Committee (PGC) is a non-profit, independently governed, 100% volunteer staffed entity founded in 1964. It is assisted in its work by the Potential Gas Agency at the Colorado School of Mines which provides objective scientific and technical guidance, formal comparisons with others' estimates, training of new Committee members, representation of the Committee at industry association and professional meetings, lectures and presentations on the work and estimates of the Committee, and administrative support for report production and Committee meetings. The Potential Gas Committee consists of volunteer experts who are associated with a wide variety of natural gas industry, governmental, and academic institutions. The Committee currently has about 105 members. The PGC develops periodic, independent estimates of the U.S. natural gas resource.

The PGC's most recent report[6], the 2008 assessment released in June of 2009, estimates that the total U.S. natural gas resource base (proven reserves plus unproven resources) at year-end 2008 is 2,074 trillion cubic feet (Tcf), more than 36 percent higher than the 2006 estimate. This total reflects the highest level in the Committee's 44-year history and represents almost 100 years of supply at current consumption levels.

The Committee's year-end 2008 assessment of 1,836 Tcf unproven resources (statistically aggregated mean value) consists of 1,673 Tcf of gas attributable to traditional and shale reservoirs and 163 Tcf in coalbed reservoirs. Compared to year-end 2006, traditional and shale resources increased by nearly 519 Tcf (45%), while coalbed gas resources decreased by 3 Tcf (1.9%), resulting in a net increase in total potential resources of 515 Tcf (39%).

When the PGC's results are combined with the U.S. Department of Energy's latest available determination of proved gas reserves, 238 Tcf as of year-end 2007, the United States has a total available future supply of 2,074 Tcf, an increase of 542 Tcf over the previous evaluation (2006).

While unconventional natural gas has been a significant component of U.S. production for a long time, its contribution has grown rapidly in recent years. Notable trends include the growth in production from tight gas reservoirs in the Rockies and East Texas, coalbed methane in Wyoming and New Mexico, and shale gas in North Texas and the Mid-Continent region. The most significant contributor to this increased estimate is the increased unconventional gas resource and in particular shale gas. The growing importance of shale gas is shown by the fact that, of the 1,836 Tcf of total potential resources, shale gas accounts for 616 Tcf (33%). As shown below, these resources are widely distributed across the U.S.

[4] ICF International, *Availability, Economics, And Production Potential Of North American Unconventional Natural Gas Supplies*, The INGAA Foundation, November 2008.
[5] U.S. Energy Information Administration, *Annual Energy Review 2008*, June 2009.
[6] Potential Gas Agency, *Potential Supply of Natural Gas in the United States (December 31, 2008)*, Colorado School of Mines, June 2009.

Shale Gas Plays, Lower 48 States

Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

The growth and future importance of shale gas resources is largely due to the development and application of new drilling and production techniques. Shale formations do not allow the gas to flow freely to a well bore. Producers must "stimulate" the well by pumping high pressure fluids into the well (hydraulic fracturing) to create a network of fractures in the rock that will allow the gas to flow out.

The recent emergence of new shale plays and rapid technology changes have made it difficult for the assessment groups to develop assessments that reflect current activity. For example, the NPC assessment was published in 2003 but did not include the Arkoma Basin Fayetteville and Woodford shales because, at the time of publication, these resources had not yet emerged. Neither the NPC study nor earlier USGS and EIA studies evaluated the horizontal drilling potential in the Marcellus play in Appalachia or the Louisiana Haynesville Shale.

Published resource assessments should be viewed with an awareness of rapidly evolving technology and the emergence of large new plays. In addition, former assessed shale resources were based upon an assumption of vertical drilling and older completion technologies. Some of the assessed shale resources in older reports represent the low pressure, shallow part of a shale play that was developed in past decades, as opposed to the deeper, higher pressure area that is now the development target for horizontal drilling. The table below shows the increase in estimated shale resources in recent years as these factors have been taken into account.

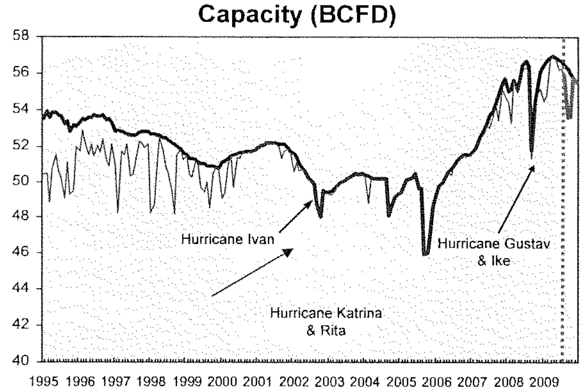
Published Estimates of U.S. Lower 48 US Recoverable Shale Gas Resource (Tcf)

USGS (various years)	NPC 2003	EIA 2007	ICF 2008	PGC 2009
85	35	125	385	616

The growing production from the Barnett Shale in the Fort Worth Basin of North Texas and the more recent startups of the Fayetteville and Woodford Shale plays in the Mid-Continent region have shown the greatly improved production potential of horizontal drilling and stimulation technologies. Many of the advances made in these technologies have come just within the past decade. In the last few years, numerous company announcements have been made about additional North American horizontal drilling shale gas plays. These include the Haynesville Shale in Northern Louisiana, the Marcellus and Huron Shales in Appalachia, the Pearsall Shale in Texas, the Utica Shale in Quebec, and the Horn River Basin and Montney Shale in British Columbia. It appears certain that shale gas production will expand in coming decades, and production will emerge in new regions in the U.S. and Canada.

The increased supply associated with unconventional gas and shale gas in particular, has fundamentally changed the supply/demand balance for natural gas in North America. Whereas gas production has been flat or declining for much of the last ten years, with no excess capacity relative to demand, production has increased in the last few years, creating some surplus deliverability and a decline in prices. With the current economic downturn, production has dropped as consumption is lagging production capacity and gas prices are still less than half of prior year levels. Even with an economic resurgence, U.S. and North American natural gas resources are now understood to be much more robust than previously expected.

Lower-48 Dry Gas Production Vs. Dry Gas Capacity (BCFD)



Source: ICF International

The Role of Gas in GHG Reduction

Interestingly, the base case modeling of the Waxman-Markey bill (and by extension of the Kerry-Boxer bill) performed by the U.S. EPA[7] and EIA[8] does not show a dash to gas. These projections show gas use flat or slightly declining, even in the power sector. The key determinants of these results are:

- Very low energy demand growth – driven by slower economic growth and/or greatly expanded investments in energy efficiency
- Very high reliance on offsets – especially international offsets – which reduces the need for domestic reductions, keeps the allowance price low and avoids the need for increased gas use
- High reliance on new low- or zero-emitting technologies such as renewables, nuclear and coal with carbon capture and storage (CCS).

When there is little or no growth in energy demand, an ample supply of offsets and rapid availability of alternative zero-emitting technologies, there is limited demand for gas. However, this combination of positive conditions may not occur. In particular most analysts expect that the supply of both domestic and international offsets will be significantly less than the maximum allowed under the bills.

Both EPA and EIA have run alternative scenarios with limited offset availability, in which they find expanded natural gas use. EIA has a case[9] with no international offsets and no new technology, which generates a 15% increase in gas consumption in 2020 and a 25% increase in 2030 compared to the reference cases. Even with this increase in natural gas consumption, the wellhead price of gas increases by $1/MMBtu (16%) in 2020 and actually does not increase from the base case in 2030. So although this fairly extreme sensitivity case does yield a significant increase in gas consumption, it does not result in a major increase in the long-term price of gas. Moreover, these cases do not include the most recent data on expanded natural gas supply, which could ameliorate the price impacts even further.

One of the important changes in the Senate bill is the delay in direct regulation of fugitive methane emissions. This allows the generation of offsets from methane sources through 2020, which would otherwise be precluded. Since the use of offsets is one of the most important cost control measures in the bill, the ability to increase the supply of offsets, could be important to ameliorate allowance prices and be mechanically simpler than direct regulation of these diverse sources.

Summary

Overall, we expect that compliance with GHG legislation will require and will occur through the use of a diverse mix of clean technologies including gas, coal with CCS, renewables, nuclear and energy efficiency. We do not expect any one to dominate. That said, we do not expect several of these options to be widely available until at least 2020, thus we do see an increased role for natural gas at least through that time, especially if availability of offsets is limited and the economy is revitalized. Fortunately, new drilling and production techniques have expanded our natural gas supply options and should allow us the flexibility to use gas as one of the options for GHG reduction.

Thank you for the opportunity to testify and I look forward to your questions.

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[7] U.S. EPA, *EPA Analysis of the American Clean Energy and Security Act of 2009*, June 2009. http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis.pdf

[8] U.S. Energy Information Administration, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*, Report #SR-OIAF/2009-05. August 2009

[9] U.S. Energy Information Administration, http://www.eia.doe.gov/oiaf/servicerpt/hr2454/excel/hr2454nibiv.xls. August 2009

ICF INTERNATIONAL

October 29, 2009

Chairman Barbara Boxer
Ranking Member James Inhofe
Senate Committee on Environment and Public Works
410 Dirksen Senate Office Building
Washington, DC 20510

Dear Chairman Boxer and Ranking Member Inhofe:

Thank you for the opportunity to testify yesterday on natural gas issues related to greenhouse gas reduction. My responses to the follow-up questions are provided below.

Question from: Senator Bernard Sanders
1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Answer:
ICF recognizes the high value of energy efficiency in general and in particular as part of a greenhouse gas reduction strategy. ICF has worked extensively with federal and state agencies to develop and manage energy efficiency programs and is one of the nation's leaders in development and implementation of efficiency programs for gas and electric distribution companies. That said, our corporate policy is to not take positions on legislative and policy proceedings in order to maintain the objectivity of our work for public and private sector clients. Thus we cannot take a position on the specific legislative provision referenced in this question.

1655 North Fort Myer Drive — Arlington, VA 22209-3117 — 703.528.1900 — 703.528.5106 fax — icfi.com

Question from: Senator James M. Inhofe

1. Your company uses a proprietary model (IPM) in its work for EPA. Without full public access to your model, it appears that any analysis that EPA conducts would be in violation of the Information Quality Act. Can you please explain why your use of the IPM model, without full public access, does not violate the IQA? Will you make the model that you use for EPA's climate modeling available to the public so we can independently validate your model?

Answer:
I do not work on ICF's IPM support for the EPA but my understanding is that the EPA has addressed this question in the past and has determined that the use of IPM is not a violation of the Information Quality Act. Moreover, the IQA regulates the activities of federal agencies and it would be inappropriate for ICF to respond on EPA's behalf on this topic. I respectfully submit that it would be more appropriate to direct this question to the EPA.

Please let me know if you have any further questions. Thank you again for the opportunity to testify.

Sincerely,

Joel Bluestein

Joel Bluestein, P.E.
Senior Vice President

Senator BOXER. Thank you. And I wanted to point out that we have worked very closely with ANGA, the American Natural Gas Association, and they have been very, very helpful. And there has been so much news about natural gas finds. It is very good news, I think, for the environment.

And now we turn our two witnesses that were cordially invited by the minority. We welcome you here. The first one is Barry Hart, Chief Executive Officer, Association of Missouri Electric Cooperatives.

Thank you for being here.

STATEMENT OF BARRY HART, CHIEF EXECUTIVE OFFICER, ASSOCIATION OF MISSOURI ELECTRIC COOPERATIVES

Mr. HART. Thank you, Senator Boxer. I thank the committee for inviting me to participate today.

I am proud to represent all of the great folks back in Missouri, the Show Me State, that own their own electric co-ops. I do appreciate this opportunity, and I want to thank Senator Bond for calling me. But I also want to thank our junior Senator, Senator McCaskill, for what she is doing for our State. And I would be remiss if I did not tell the Governor of our State, Jay Nixon, hi from the Nation's capital. He is a good friend of mine.

Let me give you an idea of our customer mix in Missouri, who we represent and their situation. That might give you a snapshot of what is going on out there. Presently, electric cooperatives in Missouri represent 2 million people that are getting electricity from 40 not-for-profit consumer-owned electric cooperatives.

These consumer-owned electric cooperatives operate in the best interests of the consumer who owns them. And because we have done a good job of that over the years, we have 91 percent customer satisfaction ratings in our State. We are very proud of that.

Let me give you a snapshot of some of our members in these small rural communities in Missouri. One-third of our members are 65 years of age or older, 83 percent of that group are retired and are living on a fixed income. Half of our households in our State earn less than $40,000 a year.

It is tough times for these folks. They work in the ag, timber and tourism industries. And they cannot, a lot of times, pass these additional costs along. So that makes them sensitive to price increases.

We have a long history in our State of working for our members, bringing electricity to the communities and economic development for our rural communities. We like to lead the way in rural Missouri.

We would like to continue that commitment today in working on the energy issues of our country and our State. We are very proud of the fact that as co-ops in Missouri we were the first in our State to develop large scale wind projects. Presently in Northwest Missouri we have 300 megawatts of wind under contract. And our communities are supporting those projects.

We are also investing in efficiency for our members. We have dedicated $31 million of co-op member money toward Energy Star appliances, energy audits, ground source heat pumps, and CFLs.

We are very proud of the fact that in the last year we have installed 2 million CFLs in our members' homes.

We are also one of the first utilities in the Midwest to join the Chicago Climate Exchange, and we are trying to do something about our carbon footprint in Missouri.

Our consumers started looking at this issue right after the House passed the legislation. They started hearing about all of these different studies that were done, and the studies had conflicting costs associated with them. So, they asked us to do our own study. And because our consumers asked us, we felt we had better get on it.

So, we asked all of the investor-owned utilities, the municipal utilities and co-ops in our State, the people that are generating electricity every day, to come together and look at the Waxman-Markey bill and tell us how much it is going to cost our consumers.

The results are staggering, and it got our members' attention. They are looking at 12 to 26 percent rate increases in 2012, which could go up to 50 percent under different cost scenarios. The impacts to our State are a lot larger than what a lot of people thought. We also are looking at 20 to 42 percent rate increases in 2020, and those could reach as high as 77 percent under the worst case scenario.

As we review the Senate bill, and we know you have put a lot of hard work into this bill, and as some of the other testifiers have said, you have tried to work on consumer protections. But this bill is not good for Missouri. I have to be honest with you. We only get out of this bill 60 percent of the carbon credit allocations that we need, and we have to pass those costs on to our consumers.

And I agree with some of the earlier testifiers that the carbon credit allocations need to benefit consumers because they are the ones that we are asking to pay the bill.

We want to work with the Senate, any Senate committee, any of the Senators, to get a bill that protects consumers and meets the goals of the United States of America. And we will stand ready to work with anybody, anywhere, anytime to meet that test.

Presently, we do not think the committee's bill meets that test. I am going to take it back to our consumers in Missouri. I am going to present it to them. And I will get back with both of our Senators and let them know what the consumers are telling me back home.

Thank you for the opportunity. But I do have to caution you, I am just afraid that if I take that 60 percent allocation back to our members, our consumers in our State, they are going to tell me to ask both of my Senators to vote no on this bill.

Thank you for the opportunity.

[The prepared statement of Mr. Hart follows:]

Testimony of Barry Hart
Chief Executive Officer
Association of Missouri Electric Cooperatives

Committee on Environment and Public Works
October 28, 2009

Thank you for inviting me to provide the views of electric cooperatives on pending climate change legislation before the Senate. I am Barry Hart, CEO of the Association of Missouri Electric Cooperatives. I represent more than 2 million people receiving electricity from 40 electric cooperatives serving more than 70 percent of the land mass in Missouri.

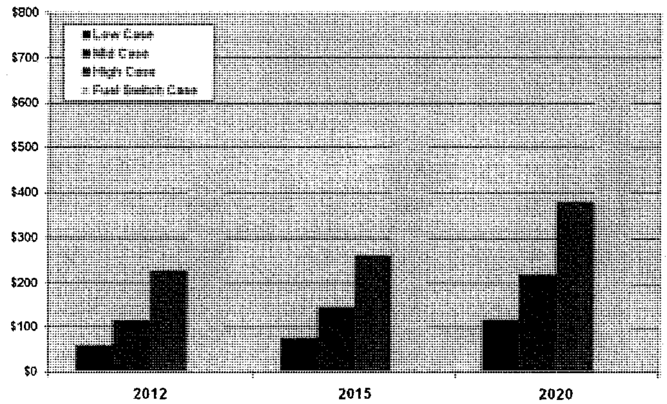
Without exception, our cooperatives are democratically governed, our business meetings are well attended and our cooperatives receive extremely high customer approval ratings.

While our members are a diverse group, we serve a high percentage of economically disadvantaged Americans. One-third of our members are 65 years or older, with 83 percent of that group retired and living on a fixed income. Nearly half of our member households earn annual gross incomes of less than $40,000.

Cap and trade proposals being considered would significantly increase costs to Missourians just as they are beginning to shed some of the financial challenges imposed by one of the deepest recessions in the last half century. There are numerous conflicting statements circulating about the cost of climate change legislation on consumers. Most studies use an average from across the nation. Missouri's electric utilities felt our consumers should know what these impacts are on our state specifically. For this reason, a joint study was commissioned by the cooperative, investor-owned, and municipal utilities to come up with cost impacts for their plants in our state.

This study shows the Waxman-Markey House bill will cause our customers to pay rate increases averaging between 12 percent and 26 percent starting in 2012 with the potential to reach as much as 50 percent should utilities be forced to switch from coal to natural gas for a significant portion of their fuel. Because the cap on emissions is reduced annually, rate increases of between 25 percent and 42 percent may be experienced as soon as 2020 and could reach as high as 77 percent under a switch to natural gas scenario. The study is included in my written testimony submitted to the committee.

Avg Increase in Annual Resid Electric Bill in MO Under Waxman-Markey
(not including other fuel and infrastructure related rate increases)



Electric cooperative members in Missouri are very concerned about possible rate increases and their impact on their families and businesses as the Senate works to craft climate change policy. That fact is evidenced by the more than 750,000 messages sent to our elected officials by Missouri electric cooperative members asking them to keep electricity affordable and reliable. We have never seen this level of grassroots involvement on an issue in our cooperatives' history.

Our members have told us they cannot afford a massive hike in rates. Unemployment is on the rise, with unemployment rates as high as 12.7 percent in rural counties. Our state's economy is reeling from recent plant closings, particularly at the St. Louis Chrysler and Ford automobile assembly plants. Our electric co-op members are predominantly employed in agricultural or timber endeavors that do not let them recover increases in production costs such as electricity. Already wholesale rates have increased 49.5 percent due to a number of factors and our member-consumers have told us their budgets are being stretched thin.

To serve our members with affordable and reliable electricity, electric cooperatives in Missouri have built a diverse generating portfolio that includes coal, natural gas, hydropower and wind energy. In fact, we were the first utility to bring wind energy to the state, with 300 megawatts currently contracted for from wind farms in Missouri.

We also have allocated $31.2 million over five years for an energy efficiency plan with a goal of reducing demand by 1.9 million megawatt-hours. Through this plan, more than 2 million energy efficient CFL light bulbs have been distributed to members, along with energy audits and rebates to install Energy Star rated appliances.

However, we are dependent on coal to supply 81 percent of our members' needs. When our last baseload plant was put in service in 1982, coal was our only option because changes in federal policy took natural gas and nuclear power options off the table.

Twenty-seven years later, Missouri consumers see themselves about to be penalized for following federal policy and making the only decision that would meet our members' needs.

We are proud of the environmental record of Associated Electric Cooperative, which provides generation for most of our members. Over the past 14 years, Associated has invested more than $1 billion to reduce emissions. As a result, sulfur dioxide and nitrogen oxide emissions are down 90 percent. In the next 10 years, we expect to spend an additional $1.3 billion on environmental improvements.

Missouri's electric cooperatives are proactive in managing their carbon footprint and are at the forefront of research on reducing carbon emissions. Associated Electric Cooperative was one of the first utilities to join the Chicago Climate Exchange, the world's first and North America's only legally binding greenhouse gas emissions tracking program. We are partnering with several Missouri utilities to fund a three-year project to study the viability of storing CO_2 underground in Missouri's unique geology. In addition, Missouri's electric co-ops are working with two universities to determine whether algae can capture CO_2 from power plant flue gas and produce beneficial byproducts like biodiesel. However, those projects will require many years of research before they are commercially viable.

Today I am here as a representative of the electric cooperative program in Missouri to talk to you about a prudent carbon policy that protects consumers. In the cooperative spirit, Missouri electric cooperatives will work together with the nation's electric cooperatives, our Senators, and this Committee to craft a climate policy that both achieves emission reductions and keeps electricity affordable for our consumer-members. Climate legislation must be:

- **Fair** – Climate change legislation must take into account regional differences. Missouri's electric cooperative consumers should not be asked to pay more than consumers in other parts of the country because of regional differences in how electricity is produced.

- **Affordable** – Any climate change plan must keep electric bills affordable for all Americans. Missouri's rural electric cooperative consumers, with a median household income more than 11 percent below the national average, cannot afford the significant cost increases projected to result from the American Clean Energy and Security Act of 2009.

- **Achievable** – Climate change mandates must be realistic to ensure long-term success. Prudent climate policy must build a bridge to a low-carbon economy responsibly and carefully.

Following are some specific areas that electric cooperatives would like to see improved in climate change legislation.

Achievable Emission Caps and Timelines

Large-scale reductions in greenhouse gas emissions will require a transformation in the electric sector on an extraordinary scale. The Kerry-Boxer bill's target of a 20 percent reduction in greenhouse gas emissions by 2020 is far too aggressive. Missouri's electric cooperatives' generation portfolio is currently 81 percent coal. In the near term, we have relatively few technology choices available to reduce our greenhouse gas emissions. Our energy efficiency programs and additional renewable energy will yield some reductions. But in the absence of new, commercially available technologies, it is likely that we would need to switch from coal to natural gas to comply with the caps in the bill, at substantial cost to our consumers.

Long-term emissions reductions can be achieved if there is sufficient new research, development, and deployment of new technologies that reduce or avoid emissions of greenhouse gases. In the utility sector, this research program must include renewable energy, nuclear power, carbon capture and sequestration, energy efficiency, and other technologies that will give us the tools necessary to accomplish the long-term reduction goals. However, it is critical that the target during the first decade of a climate program reflects the expected availability of technology.

Legislation should also allow sufficient time for the EPA, other agencies, and covered sectors to establish regulations and prepare for the implementation of the program. Attempting to begin a carbon reduction program in 2012 may well create a "false start" that could seriously imperil the very beginning of this long-term effort to decarbonize the economy. Further, emission reduction targets and timetables that are too aggressive will make the cap-and-trade program unaffordable, unworkable, and technologically unachievable.

Protection of Electricity Consumers by Allocating Allowances to Local Distribution Companies Based on Carbon Content of Fuel Mix

Currently, the Kerry-Boxer bill retains the allocation methodology in the House bill—the so-called "EEI 50-50-50" formula—leading to significant regional disparities in how well electric utility consumers are protected from rate increases resulting from the cap-and-trade program. Under the House bill's formula, Missouri's electric cooperatives would receive about **68 percent** of their proportionate share of the cap in 2012 in contrast to some utilities that would receive 100 percent. This places a disproportionate burden on our consumers due to our higher than average percentage of coal generation. As a result, our consumers—with lower than average median income—get less protection from the cost impacts of this bill just because they live in Missouri. This regional disparity is patently unfair.

The root cause of the disparity—the 50-50-50 formula—should be fixed. The most efficient method of minimizing the costs of a carbon reduction program to our electric consumers is to freely allocate allowances to local distribution companies on the basis of emissions. The utility sector should receive allowances in proportion to its share of the overall cap established in the bill (approximately 40 percent), and those allowances should be provided for the duration of the program. Further, providing allowances to unregulated merchant coal generators dilutes the allowances provided to protect electricity consumers, instead providing additional profits to those companies. Those problems can and must be avoided by allocating allowances solely on the basis of emissions.

In the case of not-for-profit, member-owned electric cooperatives, it is impossible for us to profit from the free allocation of allowances. Our member-consumers directly bear all costs resulting from efforts to reduce emissions to cap levels and acquire allowances. Likewise, our member-consumers directly save on their electric bills when costs are avoided. A program design that requires cooperatives to purchase allowances will raise costs to our consumer-members for compliance, redirecting funds that they could have otherwise invested in low-carbon technologies. Allocating allowances based on the carbon content of the fuel mix recognizes regional differences in generation and will ensure fairness and affordable electricity for all American consumers.

Robust Cost Containment Measures to Promote Economic Sustainability

Cost certainty is critical in the early years of a greenhouse gas cap-and-trade program as covered sectors transform to low-carbon energy sources. Different analyses of cap-and-trade legislation have come to different conclusions about what it will cost consumers. Even government analyses contain several different scenarios with wildly differing results, depending upon the assumptions used in the scenarios. We believe that any legislation should include a guarantee that the cost of the legislation to our consumers would not exceed a pre-determined level.

The best method of assuring cost certainty is the inclusion of a strong cost containment mechanism, such as a safety valve or price collar. A safety valve limits the potentially destabilizing impacts of a cap-and-trade program on energy prices and ensures affordability of electricity to our member-consumers. The Kerry-Boxer bill contains a strategic reserve proposal similar to the House bill that does not place an upper limit on the cost of emission allowances. While some components of the strategic reserve have improved in this bill, additional improvements such as a real price collar are needed.

Offset Credits to Provide Flexibility

The inclusion of workable domestic and international offset credit programs will provide covered sectors flexibility in planning cost-effective investments in low-carbon technologies and reduce costs to consumers. Workable domestic and international offset programs are critical to protecting consumers, particularly in the early years of a climate program. EPA, CBO, and others have concluded that the cost of emission allowances would rise by 70 to 100 percent if domestic and international offsets are not available.

This bill delays the establishment of an offset program—and thus its market value in controlling the costs of the cap-and-trade program and protecting consumers—by failing to assign the lead agency or agencies for domestic and international offset projects, and failing to include an initial list of eligible domestic project types. Cooperatives believe that the U.S. Department of Agriculture is in the best position to work with farmers and landowners on domestic offset projects. In addition, it is not necessary to cap the use of offsets by covered entities, as the size of the domestic and international offset programs will be limited by the available verified, cost-effective offsets.

Establish a Single, Integrated Program

A workable piece of legislation will ensure that regulated entities understand the "rules of the road" and know who the "traffic cop" is on that road. To make new legislation workable, it should not simply be layered upon existing law at the federal, state, or local level. Therefore, climate change legislation should establish a single, organic new law that establishes the sole legal and regulatory requirements for reducing greenhouse gas emissions, and should ensure that the Clean Air Act, Endangered Species Act, and other federal laws cannot be used to require reductions in greenhouse gas emissions. Additionally, given the nature of the climate change issue, there is no benefit to allowing states to establish "more stringent than" programs when there is a national cap established on emissions.

Unfortunately, the Kerry-Boxer bill would result in the worst-case scenario of simply layering a new set of requirements on top of existing laws that were never designed or intended to regulate greenhouse gas emissions. It also fails to effectively pre-empt states and other units of government from establishing their own cap-and-trade systems. Pancaking new and old laws and regulations must be avoided in new legislation.

Technology Development and Deployment Incentives

To make greenhouse gas reduction requirements achievable, we will need new, cost-effective technologies to reduce emissions. Incentives for new technologies (including carbon capture and sequestration, plug-in hybrid electric vehicles, renewable and nuclear power, etc.) are critical to the sustainability of any new legislation and the achievability of the emissions reductions. Developing new technology is critical to cooperatives' ability to use abundant, domestic resources like coal to continue to meet our energy needs.

With respect to carbon capture and sequestration, this bill contains several of the financial and regulatory incentives necessary to develop the technologies. However, to ensure the timely development of carbon capture and sequestration, regulatory and liability hurdles must be addressed in the legislation. Without these provisions the program will not be achievable or affordable.

Conclusion

Thank you for the opportunity to testify at today's hearing. Electric cooperatives have concerns and suggestions regarding the details of climate change legislation in addition to the elements covered above. Mandatory efforts to reduce greenhouse gas emissions will have far-reaching impacts to the U.S. economy with the potential for disproportionate impacts to low- and fixed-income households, to specific economic sectors, and among regions. A well-designed climate change program will distribute the costs of the program fairly and equitably. Cooperatives look forward to working with Members of this Committee, other committees with jurisdiction over various aspects of this issue, and the entire Senate to develop a fair, affordable, workable, and technologically achievable program. I look forward to answering the Committee's questions.

August 31, 2009

U.S. Senator Kit Bond
274 Russell Senate Office Building.
Washington, D.C. 20510

U.S. Senator Claire McCaskill
Hart Senate Office Building, SH-717
Washington, D.C. 20510

Dear Senator Bond and Senator McCaskill,

As leaders of Missouri's electric service providers, we are joining together to share our common concerns about the likely impacts of the climate legislation which will be considered later this year in the Senate. If it passes there, then Members of the House who voted on H.R. 2454 – the American Clean Energy and Security Act of 2009, a.k.a. the Waxman-Markey bill, may have an opportunity to vote again on similar issues.

As it exists today, this bill will significantly increase costs to Missourians just as they are beginning to shed some of the financial challenges imposed by one of the deepest recessions in the last half century. We believe this legislation will cause our customers to pay rate increases averaging between 12% and 26% starting in 2012 with the potential to reach as much as 50% should utilities be forced to switch from coal to natural gas for a significant portion of their fuel if natural gas prices are at the levels seen last summer. Because the cap on emissions is reduced annually, rate increases of between 25% and 42%, may be experienced as soon as 2020 and could reach as high as 77% under the switch to natural gas case cited above. Lower rate increases could be recognized if the provisions detailed below were incorporated into the legislation.

It should be noted that these projected increases would be in addition to any other rate increases that utility providers would implement to pay for higher costs of fuel, additional or improved emission control devices, increased costs of transmission and distribution, etc.

These increases represent statewide averages, with some utilities having to charge more and others less. Because Missouri utilities, and most other states in the Midwest, have historically relied on coal to produce reliable and low cost electricity, residents and businesses here could experience among the highest rate increases in the nation.

Based on the current legislation, Missouri utilities will have to find a way to cover at least 40% of their expected carbon emissions in 2012 **in addition to** the free allocations provided in the legislation. To comply with the law we will have to make costly changes to our generation fleet, operate higher cost gas-fired generation, purchase domestic and/or foreign carbon offsets, purchase more expensive low- or zero-emission power, and switch fuels in existing plants. This will be in addition to the energy efficiency efforts that will reduce our customers demand for power. Even after taking these costly measures, we will be required to purchase carbon allowances in a market with highly uncertain prices.

If the current bill could be modified in the following six ways, rate impacts on Missouri residents and businesses could be significantly reduced and yet the key environmental policy objectives maintained.

- Reduce initial consumer price shock by providing sufficient allowances to meet allowed carbon emissions, recognizing that allowances can be withdrawn over time.

- Significantly extend the current timeline before reducing allocations to give utilities a reasonable time after federal regulators have designed the regulatory plan in order to achieve meaningful reductions in carbon emissions. A more gradual 'glide slope' for reductions of allocations is needed to avoid unprecedented and very expensive actions by the utility industry, which will be borne by their customers.

- A 'price cap' should be established to prevent price spikes caused by shortages or speculation that will ultimately shock consumers' pocketbooks.

- Create an enforcement 'off ramp' so that American industries aren't forced to choose between relocating operations to competitor countries (who require little or no carbon regulation), and going bankrupt in a world market. Without this provision we could see jobs going overseas which, counterproductively, would serve to *increase* worldwide carbon emissions.

- Electric utilities, and the electrification of vehicles, are the most obvious means of reducing U.S. dependence on foreign oil. The current provisions of this legislation penalize electric utilities and their customers for advancing this national interest. Instead utilities should be allocated *additional* allowances tied to electric vehicle penetrations to speed the transition to electric vehicles.

- The proposed legislation contemplates the use of domestic and international 'offsets' as a means of addressing carbon emissions. However, it is highly restrictive with no clear timeline or guidelines for issuing a final rulemaking. Restrictions and limitations on the use of offsets should be removed. Moreover legislation must ensure that offset rules are quickly finalized to ensure their immediate availability at the start of any carbon reduction program.

If you have any questions regarding these recommended modifications to the legislation or would like to receive additional data on how climate legislation will disproportionately impact Missourians, please do not hesitate to contact us.

Sincerely,

Jim Jura,
CEO & General Manager, Associated Electric Cooperative, Inc.

Warner Baxter
President & CEO, AmerenUE

John Twitty
General Manager, City Utilities of Springfield

Bill Gipson,
President & CEO, The Empire District Electric Company

William Downey,
President & COO, Great Plains Energy and Kansas City Power & Light

Barry Hart,
Exec. Vice President & CEO, Association of Missouri Electric Cooperatives

Duncan Kincheloe
General Manager & CEO, Missouri Public Utility Alliance

Warren Wood,
President, Missouri Energy Development Association

Unified Missouri Electric Utilities Review

of the

Impacts of H.R. 2454 – the American Clean Energy and Security Act of 2009

Electricity prices are a considerable factor in siting and retaining a vibrant manufacturing and commercial consumer base in any community. These industries then provide many of the jobs that are critical to the economic health of these communities. Low electricity prices also allow many individuals in our state to enjoy an improved quality of life.

Missouri's electric service providers (municipal, cooperative and investor-owned) share several concerns that legislation like the Waxman-Markey bill will dramatically drive up the cost of electricity unless several issues are addressed. Following passage of the Waxman-Markey bill by the U.S. House of Representatives, all of Missouri's electric service providers met and worked through the major provisions of this legislation in order to understand the impacts of the legislation on our customers. These utilities then developed a reasonable set of common assumptions so that total state impact data could be developed. The observations and charts that follow were developed by this group and represent the collective thinking of the analysts most familiar with Missouri's electric generation and delivery infrastructure and how the Waxman-Markey bill would impact its operation.

Numerous reports with national 'average' data are being distributed on an almost daily basis. What these reports typically fail to address is the disparity of impacts between Midwestern and coastal states. Missourians are disproportionally impacted by this legislation due to our higher than average percentage of coal generation and lower than average median income.

The following charts illustrate low, mid, and high cases for which all the signators to this letter have provided data. In addition the signatories provided data to identify impacts associated with the need to switch fuels if other compliance options are not available in a timely manner.

The low case assumes an initial carbon price of $12 per metric ton consistent with the prices modeled by the U.S. Environmental Protection Agency. This case is only considered achievable if the concerns in the cover letter are addressed such that needed technologies are commercially available and deployable, international and domestic offsets are readily available, and economic growth is below historic levels. Given that the U.S. EPA, Energy Information Administration, and others have indicated uncertainty on these conditions, the only way to assure the carbon price in the low case is to set a price cap on the price of allowances that will likely be required to be purchased.

The mid case assumes an initial carbon price of $25 per metric ton. This closely matches much of the modeling by other organizations studying the impacts of Waxman-Markey. This scenario reflects assumptions similar to those used by several organizations whose analysis yielded 'average' impacts that do not reflect the disparity of impacts to Missourians.

The high case assumes an initial carbon price of $50 per metric ton. This carbon price level is reflected in many models used by other organizations under scenarios where offsets are not readily available and/or large-scale carbon reduction technologies are not commercially deployed until after 2020.

The fuel switch analysis captures the effect of achieving compliance with carbon reduction requirements through fuel switching (typically by reducing output from coal-fired plants and turning to natural gas-fired plants). This analysis was conducted to determine the rate impacts on customers that would occur if compliance could not be achieved through areas such as offsets and technology deployment in the short term. If utilities are forced to comply with this legislation through fuel switching for some period of time, this analysis gives scale to the customer impacts that could be observed. For this analysis, we used natural gas prices similar to those experienced last summer.

Consumer behavior, economic conditions, availability of international and domestic offsets, allowance prices, allowance allocations, and the commercial availability of large scale greenhouse gas reduction technologies (e.g. large scale carbon capture and storage) will determine what costs electric consumers will experience.

It should not be assumed that any one scenario will be observed exclusively. One plausible outcome is that initially the lower cost scenario would be observed but tightening emission caps, low availability of offsets, and slow technology deployment and the higher allowance prices that would result could push cost toward the high case.

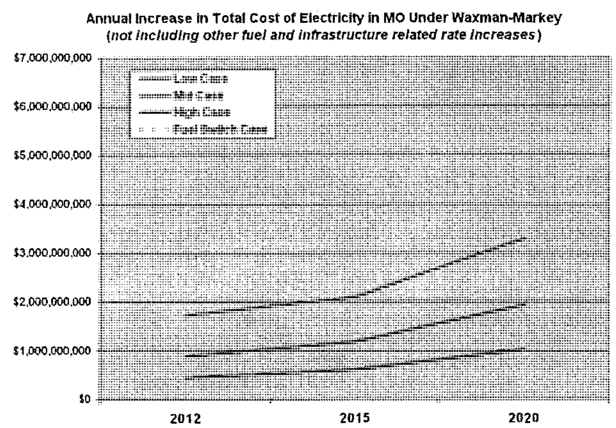
If we assume that the Waxman-Markey bill is changed so that there is a cap on the price of allowances (limiting the price to one within our assumptions) and further if we assume that the bill is changed to allow for more carbon offsets, both domestic and foreign, such that we can be assured of enough allowances at a given price, then the prices will likely be close to the low and mid cost scenarios.

If, however, the bill is not changed, and there is no cap on allowance prices nor the ability to bring in sufficient outside offsets to continue operating our coal-based units, then it is much more likely that companies will experience the high cost scenario with potential price spikes resulting from fuel switching from coal to natural gas until other cost effective greenhouse gas reduction technologies (e.g. carbon capture and sequestration) are deployed. These price spikes could be consistent with the range of prices seen in the fuel switch analysis.

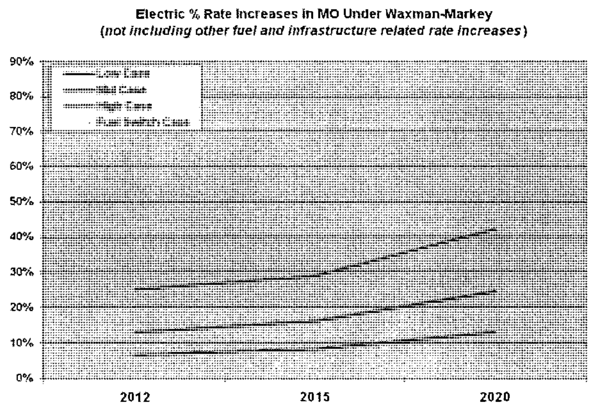
The costs impacts from this analysis are likely conservative or lower than will actually be experienced by customers under each of the analyzed scenarios. This is because none of the analysis included additional impacts from costs of operation associated with other requirements such as the Clean Air Act that are beyond that of compliance with Waxman-Markey. Additionally, the risk is greater that costs will be higher than the amounts projected because sufficient and affordable carbon offsets may not be available, new technology may not be either developed or deployed in a timely manner, and capital for plant investment may not be available in time to meet the enforcement deadlines. Finally, this analysis only addresses the impact on direct electricity costs to the consumer and does not make any effort to project the impact of higher energy prices on other goods and services that consumers purchase.

Also, it is important to note that these observations and charts are only for the timeframe from now to 2020. It was widely recognized by the analysts developing the information in this report that impacts after 2020 would only be more significant – especially when the free emission allocations phase out after 2025. Providing data between 2020 and 2030 was discussed at length but the number of uncertain variables with dramatic impacts on outcomes was viewed to be so significant as to make any one scenario just as likely as any other. Suffice it to say, we believe impacts between 2020 and 2030 will be much greater than those between 2012 and 2020 especially given the greater level of emissions reductions and the lower allocation of allowances.

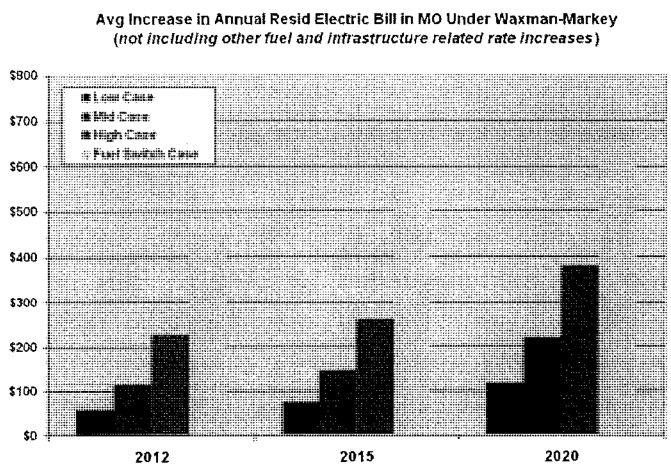
As illustrated below, just the carbon emission compliance portions of the current Waxman-Markey bill would drive up the annual cost of electricity in Missouri between $2 billion and $3.3 billion by 2020 and under conditions that force large-scale fuel switching to achieve compliance an annual impact of $6 billion could be observed. As previously noted, the availability of low cost offsets, the commercial availability of large scale greenhouse gas reduction technologies that do not yet exist, emission allowance prices, allowance allocations, and economic conditions drive the uncertainties in these estimates.



By 2020 the carbon emission provisions in the current legislation would drive electric rates 25% to 42% higher than they would be absent this legislation. If significant fuel switching is required to achieve compliance the rate impacts could approach 77%.



As shown here, this would result in a per-household annual increase in electric bills of $220 to $380 by 2020 and under conditions that force large-scale fuel switching the impact could be $690.



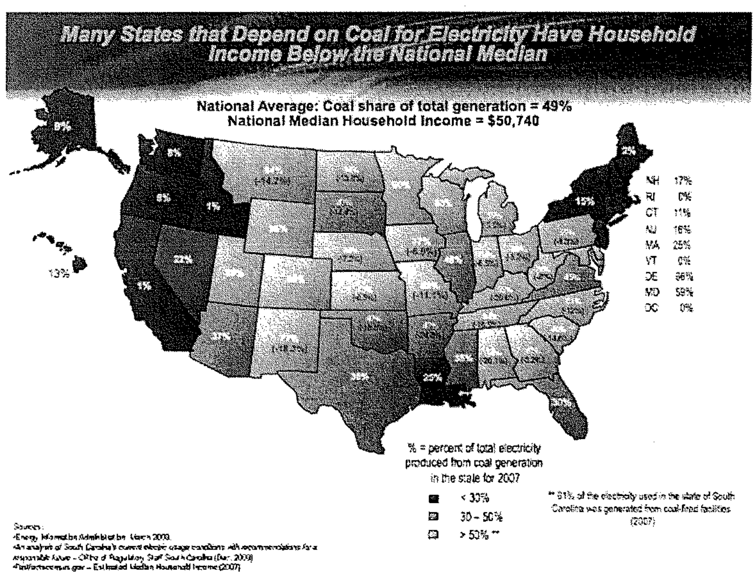
Unfortunately this increase in electricity cost will show up in everything you buy, not just your electric bill. Virtually all products either use energy in their production or transportation. Products like aluminum, concrete, and automobiles, which require large amounts of energy to produce, would be particularly hard hit.

In Missouri, 82% of our generation comes from coal and the median household income is more than 11% below the national average. Climate legislation must provide the country with an appropriate amount of time to gradually upgrade our mix of resources toward low and no carbon emitting plants, the cost of which in itself will be significant, and achieve greater energy efficiency in the communities we serve.

Our state cannot afford an immediate imposition of significant costs on power plants and manufacturers at prices set in a highly volatile and uncertain market. Climate legislation must take into account regional differences. Additionally, climate legislation should not provide an avenue to "pay for" issues unrelated to the environment such as health care reform or tax cuts for middle to low-income workers. Those issues must be addressed separate from environmental legislation, which impacts the country on a disproportionate basis.

As discussed previously one of the important variables affecting the impacts of this legislation on Missourians is the availability and price of domestic and international offsets. While we support greater access to offsets, it is important to note that one of the likely unintended consequences of this aspect of the legislation is that it may result in a large transfer of wealth from our region to other countries (to purchase international offsets). While this may be desirable in terms of minimizing rate impacts on Missourians, it is questionable policy to spend billions of dollars to purchase offsets and send this money to countries that may be doing nothing to reduce their carbon emissions and may in fact be competing with us economically.

We have enclosed a map illustrating the top coal generating states. We hope that you can make this available to all of the policy makers participating in this debate. Thank you for your consideration of our concerns. We look forward to following this debate in the weeks and months ahead.



Senator BOXER. And our next minority witness is Brett Hart, no, it is Dustin Johnson. I have got to get this right. I have got my wrong panel here. Dustin Johnson, Commissioner, South Dakota Public Utilities Commission, and Mr. Johnson is serving as the Commission's Chairman. Congratulations, Mr. Chairman. And we are honored to have you with us.

STATEMENT OF DUSTIN "DUSTY" JOHNSON, CHAIRMAN, SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Mr. JOHNSON. Thank you very much.

Good afternoon Madam Chairman, Ranking Member Inhofe, members of the committee.

I am Dusty Johnson. I am Chairman of the South Dakota Public Utilities Commission, and since I was elected 5 years ago statewide, it has been my great pleasure to fight for consumers. And I love doing it, and I know you all do as well. These folks have earned their money, and they should not have to spend any more than they have to on their natural gas and electric bills.

And that is really what brings me here today. I understand the desire to reduce our carbon footprint. And I think we should. But I am concerned that this bill is not fair, and I am concerned that it hurts consumers, especially Midwestern consumers, far more than it has to.

What do I mean? Well, this bill, I think, first hurts Midwestern consumers by significantly increasing their utility bills. Our analysis indicates that bills in South Dakota are going to go up 25 percent between now and 2012. And that is just to pay for allowances. That is not to clean up anything, or to build anything new. That is just to pay for the allowances. And that is about a quarter of a billion dollars a year hit for South Dakota. And I just do not know how you can take a quarter of a billion dollars out of South Dakota every year and not hurt families and businesses.

Of course, those price spikes are going to come at a time when we are already seeing electricity prices increase pretty significantly, and we are seeing that in South Dakota. Black Hills Power has already asked us for a 27 percent rate increase, Xcel Energy has asked us for an 11 percent rate increase, and most of those costs are related to Xcel trying to get cleaner.

Let us be honest. Building new wind power, building new transmission lines, converting coal power plants to natural gas power plants, as they are doing, that stuff does not come cheap. And we are getting greener in South Dakota. We are very proud of that. But that does cost serious money.

So I think that is my big concern. You get that double-barreled shot of folks having to pay for allowances while at the same time having to pay to green up their energy sources. That is going to have an impact on consumers, and I do not think anybody can deny that. You all have heard CBO Director Elmendorf has testified that the House bill would cut the Nation's GDP by 3.5 percent over the lifetime of the bill, and that impact is going to be disproportionately felt in States like mine.

Why? Because this bill, in a lot of ways, picks regional winners and losers. You look at California. Under this bill, California would receive 12 million more carbon allowances than it needs. And little

South Dakota would be left about 3 million allowances short. Other Midwestern States are left in similar situations. And that is going to mean a very real transfer of jobs and billions of dollars from our Nation's Heartland to the coasts.

That is, I think, one clear example of how this bill, at least in its current form, is bad for the Midwest. And I think, is an example of a provision that is more about politics than about the environment.

Now listen. I am a politician. And I understand that politics is about the art of compromise. But I think this bill that tries to give a little bit of something to everybody in some ways has obscured the central role of carbon regulation. What do I mean? Well, I think in some ways this bill gives our country a fish when we need a fishing pole.

People have talked about softening the impact to consumers by giving some of them rebates. But I do not want Americans to be more dependent on a check from the Federal Government to pay their utility bills. If we want to reduce our carbon footprint, and again I think we should, if we should do it, then let us go do it. Let us invest that money in nuclear and in energy efficiency and in research and development. Let us solve the problem rather than making us more reliant on the Federal Government to pay those bills.

I should mention that I am not alone here. The National Association of Regulatory Utility Commissioners, and these are the folks who are fighting for consumers every day, they do not oppose this bill. But they do agree with me on a whole lot of this. They agree allowances should be given based primarily on emissions, that compliance revenues should be invested in technology and efficiency, that the utility sector should receive a full portion of allowances, and that State commissions need more flexibility.

I am no Neanderthal and neither are my regulatory colleagues. I believe the globe is warming, and I think we should reduce our carbon footprint. One hundred percent of the generation that has come on line in South Dakota in my 5 years as an energy regulator has been renewable or low carbon. We have invested $1 billion in wind, we have new transmission lines, we have a thousand green jobs, and the ACEEE recently, just last week, named South Dakota one of the most improved States in the entire country in the last year because of our energy efficiency efforts.

I believe in a low carbon future. We are making strides in South Dakota, and I am hopeful that we can improve this bill so that it moves us farther down the field in the right way.

Madam Chairman, thank you very much for the time.

[The prepared statement of Mr. Johnson follows:]

U.S. Senate Committee of Environment and Public Works
Hearing on S. 1733 (Clean Energy Jobs and American Power Act)
Written Testimony of the Honorable Dustin "Dusty" Johnson
Chairman, South Dakota Public Utilities Commission
October 28, 2009

Good morning Chairman Boxer, Ranking Member Inhofe, Members of this Committee, and distinguished panelists. I appreciate the opportunity to appear before you this afternoon. I am Dustin "Dusty" Johnson, and I currently serve as the chairman of the South Dakota Public Utilities Commission (SDPUC). The SDPUC has been protecting consumers since 1886. Today we regulate companies in the electricity, natural gas, telecommunications, and grain storage industries. We understand how important it is to be a strong, fair, and proactive regulatory presence dedicated to the public interest.

I was elected to the Commission in 2004 and serve on the Board of Directors for the National Association of Regulatory Utility Commissioners (NARUC) and on the NARUC Electricity Committee. I have had leadership roles in a number of national, regional, and state energy committees and work groups and understand energy and regulatory policy and how it affects consumers. I am honored to serve on the SDPUC alongside my colleagues Steve Kolbeck and Gary Hanson. We are a bipartisan commission that has never let politics get in the way of working for the public interest. Our job is to fight for consumers, and we love doing it. Those consumers have earned their money and they shouldn't have to pay any more than necessary for their utilities.

That's what brings me here today. It seems like so often when people talk about the impacts of federal energy legislation, they talk about utility companies. Well, South Dakota is a traditionally-regulated environment with vertically-integrated utilities, so the utility companies don't pay for much of anything – their customers do. Those customers elected me, they're my bosses, and I'm here today on behalf of them, the people who pay the bills.

I understand the desire to reduce our carbon footprint, and I think we should. But I don't think the climate change legislation pending before you is the right approach. It will harm consumers, especially Midwestern consumers, far more than it needs to.

Direct Impact on Ratepayers

This bill will hurt Midwestern consumers because it substantially raises their monthly utility bills. Analysis done on Waxman-Markey shows South Dakota consumers will be paying as much as 25 percent more for their electricity as soon as 2012. It could be even more for customers of some companies.

- Black Hills Power estimates cost increases to be 47 percent in 2012 and 82 percent in 2030, assuming a $50/ton price on carbon emissions.
- MidAmerican Energy predicts an increase of as much as 25 percent in 2012.
- Missouri River Energy Services would see a 65 percent increase if the President's proposal of 100 percent auction were passed, but expects to see increases of 25 percent at $35/ton or 15 percent at $20/ton.
- Montana-Dakota Utilities estimates a 15 percent increase in 2012, up to a 30 percent increase by 2035, assuming emissions trading at $20/ton. At a higher price of $50/ton, they would see increases of more than 30 percent as early as 2012.
- NorthWestern Energy is expecting the average residential customer to pay an extra $250 annually with the average commercial customer paying more than $1,000 annually if the Waxman-Markey bill is signed into law.
- Assuming 35 percent free allowances, as given in the Waxman-Markey bill, Otter Tail Power Company expects to see emissions sell for $25/ton in 2012, $37/ton in 2015 and $40/ton in 2020, corresponding to rate increases of 23 percent in 2012, 37 percent in 2015, and 45 percent in 2020.

Although the chairman's mark of the Senate bill was just released late Friday night, I have taken some time to look at the 900+ page draft, and it is worse for consumers than the Waxman-Markey bill. The Kerry-Boxer bill has a more aggressive near-term target of 20 percent in 2020 and starts with fewer allowances available for allocation. The end result is a much more severe impact to ratepayers than what is outlined above.

The SDPUC has been interested in the impacts of a cap-and-trade proposal for quite some time. Last spring we hosted a Carbon Cap and Trade Forum. Prior to the event, we gathered some analyses of impacts to utility customers of recent cap-and-trade proposals. At the forum, we held panel discussions on cap-and-trade legislation, in an attempt to gather as much information as possible. After the event we wrote a report entitled, "Carbon Cap & Trade: National Policy, Local Impact." [1]

Not only did we learn how a cap-and-trade program should be structured to have the least impact on South Dakota's ratepayers, our conclusion estimated what that impact would be. Given a $30/ton price of emissions, and without no-cost allowances, we found the average South Dakotan was likely to see a near-term electricity price increase of 48 percent. That was only the direct cost of such legislation. I am glad the Kerry-Boxer and Waxman-Markey bills have included a number of the consumer-friendly provisions the SDPUC identified, but there are others I hope could still be added to minimize the substantial negative impacts to American families and businesses.

Because there is no hard price collar in the Senate bill, it is tough to say what the true limit of what the impact to consumers could be. The actual auction price will be

[1] http://puc.sd.gov/commission/Events/carbonforum/CarbonCapandTradeSummaryReport.pdf.

determined by what miracle technology sprouts from the small allocation of this bill going into research and development. It will be determined by the price of natural gas, and how much we can find and easily extract in the coming decades. It will eventually probably be determined by the price of new nuclear plants. As a result, many have suggested that climate change legislation include a price collar to minimize allowance price volatility. I agree with that. This is especially important to Midwestern states like South Dakota that will receive fewer allowances than needed under either version of the bill (House or Senate).

As I understand the current version of this bill, a minimum ceiling price is set at $28 in 2012 and increases thereafter. This minimum ceiling price fund is essentially a floor. The chairman's mark includes a reserve fund with a soft collar, but this mechanism will not do enough to protect customers. With emissions trading creating a commodity market expected to be in the trillions of dollars, I am not confident that such a mechanism would do much to limit speculation or control the price impacts to Midwestern ratepayers.

In South Dakota, we spend a little more than a billion dollars a year on electricity and natural gas. A 25 percent increase in those bills, just for an allowance cost, takes $250 million a year out of our state. Consider this: $250 million dollars across a state of slightly more than 800,000 people pencils out to more than $850 per household. South Dakotans also spend about a billion dollars a year on state taxes. Thus, the effects of this bill would be similar to a 25 percent increase in state taxes. This tax would be different, however, in that it would not provide the essential services that our state taxes do. Much of this tax would be shipped to other states, to special interest groups, to merchant generators, and to the federal government. You can't pull a quarter billion dollars out of a state like South Dakota and not cause serious damage to families and businesses.

Already Rising Energy Costs

This bill would hurt Midwestern consumers because it would raise rates at a time when prices are already expected to be rapidly increasing. A massive new capital expenditure cycle, environmental compliance, and worldwide demand for resources are all going to push prices significantly higher. We are already seeing it in South Dakota. Black Hills Power just requested a 27 percent increase. Xcel Energy has requested an 11 percent increase, much of which is being driven by their effort to get greener. Adding wind generation, building transmission lines to carry wind, changing coal plants over to natural gas – all of those things cost serious money. We recently approved a 12 percent increase for Otter Tail Power, and 60 percent of that rate increase was related to wind power. We are getting greener in South Dakota and it is already costing us serious dollars. Adding an additional 25 percent to the already rising costs is asking too much of consumers. As energy prices rise, consumers are already in the middle of an economic crunch. Increasing the price of energy even more will be devastating to many. How much more can they bear?

The costs ratepayers will carry just to add renewables to the system are now beginning to set in. The initial plans to export wind generation out of the Midwest and into areas of the country without renewable resources are being laid out and the costs are extensive. The Green Power Express is one example. This proposed network of high-voltage transmission lines spanning from the Dakotas to Illinois is estimated to cost between $10 and $12 billion, effectively doubling the value of the transmission in the region. This estimate does not include the generators being connected to the new grid. Coal plants that are in some cases less than halfway through their depreciable life will be replaced with more a more expensive mix of generators. These generation and transmission costs are in addition to compliance costs utilities will pay and be forced to pass along to ratepayers. The combination of transition and compliance costs will be massive, especially in areas like the Midwest, where three-quarters of our generation comes from coal.

For the last 100 years the real price of electricity in this country has been dropping with surprising consistency. It was among the most important developments of the 20th century and allowed electricity to become the "the lifeblood of modern society & economic growth," as noted by the Institute for Energy Research.[2] Today, as increasing world demand for resources transforms that long-standing cost curve, we may be nearing the end of the era of affordable energy. Is now the right time to implement a mechanism that would place significant additional upward price pressure on energy?

Effect on International Competitiveness

This bill would hurt Midwestern consumers because it lowers productivity and doesn't protect our international competitiveness. Of course, it's not just me who says that. CBO Director Douglas W. Elmendorf has testified that the cap-and-trade provisions of the House bill would cut the nation's gross domestic product by 1 to 3.5 percent in 2050.[3] Energy Secretary Steven Chu said that "[i]f other countries don't impose a cost on carbon, then we will be at a disadvantage."[4] The Tax Foundation has estimated similar legislation to reduce economic output by $136 billion annually and export 965,000 jobs.[5] Unfortunately, many South Dakota

[2] http://www.instituteforenergyresearch.org/energy-overview/

[3] U.S. Senate Committee on Energy & Natural Resources, Oct. 14, 2009, Testimony of Dr. Douglas W. Elmendorf

[4] "Energy Chief Says U.S. Is Open To Carbon Tariff," *Wall Street Journal*, March, 18, 2009, p. A4

[5] Andrew Chamberlain, *Who Pays for Climate Policy? New Estimates of the Household Burden and Economic Impact of a U.S. Cap-and-Trade System*, http://www.taxfoundation.org/publications/show/24472.html

businesses rely on the low cost of energy we enjoy today, and would likely be the first to go under or relocate as a result of higher energy prices. Since 2001, the price of electricity in South Dakota has risen at less than half the rate of electricity prices in the United States, and South Dakota has seen robust economic growth during that time.[6] In fact, during that time South Dakota's economy has grown at 129 percent the national average. I believe affordable energy is a powerful engine of economic growth and South Dakota is a clear example of that.

This bill does not require or even ask other nations to reduce their CO_2 emissions. The legislation doesn't include "off ramps" if other countries fail to participate. The two largest up-and-coming carbon emitters, China and India, have both indicated they place more importance on their economic wellbeing than on the concentration of CO_2 in the atmosphere. If carbon emissions and business opportunities simply transfer to other countries as a result, what is the point of capping carbon in this country in the first place? Does Congress intend to pass such an economic burden to American consumers when the results will be negligible? This one-sided approach to carbon reduction has the potential to cost South Dakota and the Midwest a substantial amount of jobs and economic prosperity.

Wealth Transfer to Coasts

This bill would hurt Midwestern consumers because it takes their money and uses it to provide a windfall to other regions of the country. Kerry-Boxer allocates free allowances 50 percent of emissions attributable to retail electricity and 50 percent to retail electricity deliveries. This methodology ensures customers of utilities that generate or purchase significant amounts of coal-fueled energy, such as many utilities do in South Dakota, will receive fewer allowances than required to offset increased customer costs when compared to nuclear and hydro-dependent utilities whose actual emissions attributable to their retail electricity sales are minimal. The recent EPA analysis on the Waxman-Markey bill allowance allocation methodology shows California is given 12 million more allowances than it needs for compliance and South Dakota would only receive two-thirds of what it needs for compliance, leaving it three million allowances short.

South Dakota is not the only state shorted by the allowance allocation. Other Midwestern states are left in a similar situation, meaning the bill transfers jobs and billions of dollars from our nation's heartland to the coasts. That isn't right and it isn't fair. It's not just me that believes that. It's also my colleagues across the country. A 2007 NARUC resolution stated, "[t]he assignment of no-cost allocated allowances to local distribution companies . . . should be based primarily on the level of GHG-emissions."[7] In the end, improper allocation of these allowances will cause

[6] According to data from the U.S. Department of Energy's Energy Information Administration

[7] *Summary of NARUC Climate Policy*, http://www.naruc.org/Publications/ClimateIssueBrief1_Apr2008.pdf

an outflow of dollars from Midwestern states, such as South Dakota, to the coastal states. These dollars, which will increase electric costs tremendously, will result in no reductions to greenhouse gas emissions. The solution to this issue is to allocate 100 percent on emissions.

Not only are the free allowances unfairly allocated, but this bill actually allocates fewer no cost allowances to utilities than Waxman-Markey. To states such as South Dakota, this can only mean costs under this version of the bill will be even higher than those under Waxman-Markey. I encourage the Senate to restore what was lost under this version and to increase the overall allowance allocation to the electricity sector from 35 to at least 40 percent to be equivalent to the sector's share of emissions.

The Kerry-Boxer bill also allocates 14.3 percent of the allocated utility sector allowances to merchant generators. Merchant generators are not rate-regulated by state PUC's (or anyone) and so there is no mechanism to ensure consumers gain the benefit of no-cost allowances. The result would be an enormous windfall of profits to merchant generators with no likely environmental or consumer benefit. It's not just me that believes that. It's also my colleagues across the country. The NARUC Climate Change Task Force has stated that, "[b]ecause merchant generators are not rate-regulated, they have no obligation to pass through benefits to consumers. Operating in a competitive market, merchant generators will likely retain the value of free allowances as profits, just as European merchant generators did."[8] This problem can be resolved by eliminating the allocation to merchant generators and instead providing those allowances to local distribution companies, which will be required to pass that benefit on to consumers.

Improper Allocation of Allowance Revenue

This bill would hurt Midwestern consumers because it gives them a fish, when they really need a fishing pole. These bills all envision softening the impact to consumers by providing some of them – the low- and middle-income – rebates to pay their utility bills. But I don't want more Americans more dependent on the federal government to pay their utility bills. If we need to reduce carbon, then let's do it. Let's put that money toward energy efficiency and toward research and development. Let's solve this problem, rather than making consumers reliant on yet another check from the federal government. We will not solve our carbon problem by under-investing in research and development, and unfortunately, the Kerry-Boxer and Waxman-Markey bills do just that.

[8] *NARUC FAQ: Consumer Benefits of Free CO Allowances for Utilities*, http://www.naruc.org/Publications/FAQ1_Consumer_Benefits.pdf

Technology is key because we don't have the tools we need to reduce our carbon footprint by 80 percent. Without technology to reduce our carbon intensity, a cap-and-trade mechanism is really just a tax. With 70 percent of our nation's electricity generated from fossil fuels, buying allowances or offsets is the short-term answer. I strongly believe any climate change legislation should include provisions that result in additional renewable and nuclear energy, energy efficiency programs, carbon storage development, and other new technologies. It's not just me that believes that. It's also my colleagues across the country. Resolutions passed by NARUC have made it clear that an effective climate change bill must, "[i]nclude support for the development of more efficient generation, transmission and distribution technologies, energy efficiency, and GHG-emission control and sequestration technologies through various means . . . "[9]

I'm not only concerned that this bill under invests in technology; I also feel that way about energy efficiency. I think efficiency will have to be a central component of meeting these goals, and I'd like Kerry-Boxer to invest more resources into efficiency, rather than into rebates. Of course, in some parts of the country or for some classes of customers rebates may be necessary. That's why a large portion of the compliance revenue should be provided to state utility commissions with appropriate discretion to design the proper mix of rebates and efficiency improvements. Some states are farther along the efficiency path and may not have as much low-hanging fruit, so they might favor a higher proportion of rebates. Other states, particularly those cold-weather states like South Dakota, may make weatherization the top priority. Each state's utilities commission is uniquely qualified to determine how best to spend that compliance revenue. It's not just me that believes that. It's also my colleagues across the country. The NARUC Climate Change Task Force has stated that, "Congress should allow flexibility to State regulators in order to encourage creative solutions that address each jurisdiction's individual circumstances."[10]

Those familiar with both logic and the electric utility industry know that those who use the SO_2 trading program as a template for a successful CO_2 cap-and-trade program are guilty of the fallacy of false comparison. Although both programs cap emissions at a specific level and allow the trading of emissions allowances to set the market price of those allowances, the two programs are different in every other way. First and foremost, when the Clean Air Act acid rain SO_2 trading program was passed, the technology was available to capture SO_2. No such feasible technology is available for capturing CO_2, meaning most generators will be looking at fuel switching or abandonment rather than simply retrofitting. The goal of the SO_2 trading program was to reduce emissions by 50 percent, not 83 percent. In addition

[9] *Summary of NARUC Climate Policy*, http://www.naruc.org/Publications/ClimateIssueBrief1_Apr2008.pdf

[10] *NARUC FAQ: Consumer Benefits of Free CO Allowances for Utilities*, http://www.naruc.org/Publications/FAQ1_Consumer_Benefits.pdf

to less aggressive goals, allowances were allocated fairly. Ninety-seven percent of the SO_2 allowances went to utilities, but not all utilities, just those that needed them. Finally, allowances are freely distributed over the life of the program, and auction proceeds are redistributed to utilities with compliance obligations. It should be obvious, then, that the success of the acid rain program provides little help in evaluating current CO_2 cap-and-trade proposals. If anything, drafters of these bills should attempt to learn something from the successful SO_2 trading program.

As I understand this bill, free allowances are to be phased out between 2026 and 2030, similar to the Waxman-Markey bill. However, because this bill does not focus sufficient resources into the research and expansion of nuclear generation and because it will take time to research and develop the energy storage, carbon sequestration, and other technologies needed in its absence, there is real potential that allowances prices could increase dramatically as our country struggles to meet the carbon reduction timelines. To soften the impact to consumers, I urge the Senate to extend the phase-out over the entire emission reduction period to 2050.

State Commission Flexibility

This bill would hurt Midwestern consumers because it doesn't allow their state regulators the flexibility to design programs best suited for their needs. State utility commissions do a very good job of setting rates and a very good job of protecting consumers – those are our areas of expertise. I'm not sure this bill acknowledges that, and so I have great concerns about the workability of the legislation, as does NARUC.[11] This bill and the Waxman-Markey bill both include language that significantly limits how state commissions can distribute local distribution company allowance proceeds. Both bills require the benefits to be shared "ratably" and "equitably" within and among consumer classes. They also appear to require industrial and residential consumers receive a direct cash rebate from allowance proceeds if it is proven the cap-and-trade system caused their energy bills to increase.

These provisions are problematic because they foster uncertainty and potential litigation. Just who will determine what "ratably" and "equitably" mean, and how will that impact the decision to issue flat rebates when the industrial and residential consumers demonstrate their power bills have increased? In addition, if Congress wants to encourage and help fund energy efficiency and clean energy projects, this language unnecessarily prohibits what would otherwise be a strong revenue stream that could be dedicated for these investments. State commissions have historically encouraged significant amounts of clean energy investment, and as we have seen with the Regional Greenhouse Gas Initiative States, proceeds from the nation's only

[11] *NARUC FAQ: Consumer Benefits of Free CO Allowances for Utilities*, http://www.naruc.org/Publications/FAQ1_Consumer_Benefits.pdf

functioning cap-and-trade market are being used for energy efficiency investment. Allowing the Environmental Protection Agency (EPA) and other federal agencies to micromanage state ratemaking isn't a good idea and I urge you to remove such wording.

Additionally, I believe some utilities could achieve the emission reductions sought in this bill without participation in the allowance trading system, and if there are some that want to, I think they should be given options on how to proceed to accomplish the goals. Companies like MidAmerican Energy don't oppose reducing emissions but are skeptical of whether a trading mechanism will result in the lowest cost emission reductions for their customers. I understand their concerns and am also opposed to sending money out of state when we could use those dollars to either reduce emissions at existing power plants or replace those plants with low-carbon alternatives.

I believe some opt-out provision should be included in this legislation. States and utilities could decide whether to participate in the allowance trading system, or instead approach the reductions directly. The emission reduction targets would remain, but the state regulators would make the decisions on the energy policy within the state and how the reductions would be achieved at the lowest possible cost. Such an approach would let states and local distribution companies focus on pursuing the most effective means of reducing greenhouse gas emissions to meet the federal caps, and give consumers a voice in the process.

Conclusion

I don't want anyone to think that these comments are coming from a caveman or Neanderthal. I believe the globe is warming, and I believe we should reduce our carbon footprint. One hundred percent of the generation that has come on-line in South Dakota in my five years as an energy regulator has been renewable or low-carbon. In the last five years, more than a billion dollars has been invested in renewable energy in my state, new transmission lines have been built, and we're home to a thousand green jobs. Just last week, the American Council for an Energy-Efficient Economy (ACEEE) rated South Dakota as one of the "most improved" states for our energy improvement efforts[12]. Clearly South Dakota is a state that is embracing the new energy economy and the need to reduce our carbon footprint. You can see similar robust green efforts in almost every state in the Midwest and Great Plains. Tremendous progress has been made, much of it in just the last few years.

I believe in a low-carbon future. I just think the bill before you is the wrong way to get our country from where we are to where we need to be. I think it places far too

[12] *The 2009 State Energy Efficiency Scorecard*, http://aceee.org/press/e097pr.htm

much of the burden on consumers and on American business and I think it will make families more dependent on the government to pay their monthly utility bills. I know we can do better. With that, I will be pleased to answer any questions.

Dustin M. Johnson, Chairman, South Dakota Public Utilities Commission
October 29,2009

Responses to Follow-Up Questions from October 28, 2009
Environment and Public Works committee Hearing

Senator Bernard Sanders

1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs ans save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

   Answer:
   In short, yes. I feel that this bill under-invests in energy efficiency. I think efficiency will have to be a central component of meeting our carbon reduction goals, and I'd like Kerry-Boxer to invest more resources into efficiency rather than rebates. And when I say rebates, I'm not talking about upfront no-cost allowances to LDC's. Of course, in some parts of the country or for some classes of customers rebates may be necessary. However, I think a larger portion of the compliance revenue should be provided to state utility commissions with appropriate discretion to design the proper mix of rebates and efficiency improvements. Some states are farther along the efficiency path and may not have as much low-hanging fruit, so they might favor a higher proportion of rebates. Other states, particularly those cold-weather states like South Dakota, may make weatherization the top priority. Each state's utilities commission is uniquely qualified to determine how best to spend that compliance revenue. My colleagues across the country feel the same way. The NARUC Climate Change Task Force has stated that, "Congress should allow flexibility to State regulators in order to encourage creative solutions that address each jurisdiction's individual circumstances."[1]

[1] *NARUC FAQ: Consumer Benefits of Free CO Allowances for Utilities,* http://www.naruc.org/Publications/FAQ1_Consumer_Benefits.pdf

Senator James M. Inhofe

1. Nowhere in the Boxer bill is there a provision that guarantees that utilities will be able to recover the costs imposed on them by the cap and trade regime. At the same time, nothing in the bill says what happens when and if a state Public Utility Commission disallows a utility to recover the enormous costs that arise from the wide range of provisions that impose new obligations on them. Certainly given the enormity of the cap and trade costs no utility is going to move forward with expensive investments in new generation or compliance costs without prior approval from their respective PUCs which will have to include prudency pre-approval for recovery of the relevant costs of those investments and expenditures.

    a. What happens to this whole process when a PUC simply decides NOT to allow cost recovery for cap and trade costs in a utility's rates?

    Answer:
    State regulatory bodies are bound by case law, and in most cases explicit state statutes, to allow recovery of all costs that were reasonable and prudently incurred by the regulated utility. In instances where utilities are simply complying with mandates ordered by the federal government (purchasing enough carbon allowances to operate, for instance), I think state commissions would have little authority to deny those costs. In the short-term, the utility has no ability to avoid incurring those mandated regulatory costs, so is not acting imprudently by complying with the law. In the long-term, as regulators reasonably presume utilities are taking actions to cost-effectively lower their carbon costs, there is greater potential for disagreement between PUCs and utilities over what course of action is most prudent.

    State commissions will be under tremendous political pressure to disallow carbon regulation costs, especially when those costs would impose a substantial burden on ratepayers, who will not be happy to see rates increase dramatically. In instances where commissions do not allow recovery of those costs, costly litigation will almost certainly follow.

    The South Dakota PUC has an abundance of orders which explicitly state that utilities are allowed to recover costs of federal mandates. Therefore any ratepayer mitigation of cap and trade costs would likely only apply to future investment decisions unless this commission chose to attempt to overturn a strong legal precedent.

    b. Can you envision any utility making the enormous capital investments or operating cost expenditures without a virtual prior-approval guarantee that these costs will be recouped in rates they can charge?

    Answer:
    If a cap-and-trade mechanism goes into effect, a variety of expensive investment decisions will need to be made. I agree that utilities will be unlikely to make such investments (whether into programs or infrastructure) without guidance or (in jurisdictions allowing it) pre-approval from their state utility commissions.

c. Isn't the Boxer bill's failure to address the political reality that PUCs are simply not going to approve massive rate increases reflecting the enormous costs of this cap and trade bill the ultimate choke point for the failure of this legislation?

Answer:
If a cap-and-trade mechanism goes into effect, it will place financial burdens on ratepayers, political burdens on state commissions, and burdens related to the uncertainty of recovery onto utilities. I view the burden on consumers as far greater than the burdens placed on either commissions or the utilities.

Utilities may face some high level of uncertainty surrounding two types of investments, though (see answer to 1d below). In instances where utilities feel they must incur costs for carbon compliance, but such costs are not adequately recovered, you are right that a "choke point" is created. Utilities caught in the middle of federal legislation and state regulators have the potential to incur substantial economic damage.

However, as seen in the early to mid-1980's with state-by-state decisions to disallow plant costs previously approved when capacity proved significantly overbuilt due to erroneous estimates of growth rates, it is impossible to predict how each state commission will address the issue. Regardless, there is no way to avoid having customers harmed through either higher rates or utility setbacks which will affect financing costs.

d. Aren't PUCs political bodes, either directly elected by the voters or beholden to their governors who certainly are elected by the voters? What makes you think that PUCs which routinely reject rate increases of a few dollars per customer are going to accept the responsibility for imposing the enormous costs of the Boxer cap and trade regime and the job losses and economic dislocation that these costs will create in their states?

Answer:
My experience has shown me that in most instances state commissioners make a decision based on the law and the facts in record, even when such a decision is politically unpopular. As a result, I think utilities are, at least initially, highly likely to receive cost recovery for expenses directly related to securing sufficient carbon allowances. I do believe there will be substantially more uncertainty surrounding recovery for investments in two areas, however.

First, a cap-and-trade mechanism may cause already existing infrastructure (e.g., "dirty" generation and the transmission facilities used to serve such generation) to be underutilized, and will impose a need to increase rates to recover costs as sales diminish. Yes, ratepayers are likely to be highly reticent to pay for facilities from which they are no longer receiving a benefit. State commissions may determine that such stranded costs are no longer appropriate for cost recovery because the utility acted imprudently by constructing such facilities in the first place. Such a ruling would be highly likely to result in expensive litigation. Second, I expect significant tension over what new investments in infrastructure or programs should be used to reduce a utility's carbon footprint and corresponding carbon allowance expense. In states that *lack pre-prudency review, decisions made by a utility will be subject to a high level of regulatory uncertainty. It is a given that the costs of building these replacement facilities will be expensive even if they are transitioned over time into the generation mix. If these facilities are forced into the mix over a short period of time the ratepayer impact will be that much greater, reflective of adding a larger percentage of new plant, and the lack of negotiating leverage for a high-demand commodity.*

In most case the plants generating the penalties have been in service for many years and it would be difficult for any commission to support a claim that the decision to build these plants was somehow now imprudent after one or more decades of service and no previous mention of imprudency.

e. What is a utility supposed to do when faced with a federal mandate from the Boxer bill and the inability to recover the costs of complying with that mandate through its state regulated rates? Will any utility move forward in the absence of pre-approval of cost recovery from its PUC? What does this reality mean for the compliance time tables imposed by the Boxer bill? Don't we need an escape clause that provides a utility a defense to EPA's penalties if a utility does not comply with the Boxer regime due to good faith inability to secure cost recovery?

Answer:
Utilities do have a mechanism to seek relief when they feel they are denied recovery of reasonable and prudent expenses. In every jurisdiction I have knowledge of, they may appeal the commission's decisions to a state court. If the court system rules that such costs may not be recovered from consumers, I am unaware of any other option available to utilities except bankruptcy.

South Dakota utilities have a statutory requirement to serve, and all have gone forward in the past to comply with that requirement even without explicit cost recovery assurance from the PUC. Time necessary to achieve state approval or a favorable court decision will be a concern to utilities, but an additional concern in our part of the world is that our utilities generally serve in multiple states. Achieving necessary approvals can be difficult, and can also create additional costs among states if not all states are on the same page when making determinations.

Escape clauses have been an issue when setting renewable targets as securing resources as basic as steel for generation facilities and the large amount of new necessary transmission line, and skilled labor to construct can be difficult. Issues related to regulatory approval could cause further delay as a standalone issue, or as an issue which delays ordering of necessary materials to construct generation facilities.

2. The Boxer bill purports to limit the number of allowances that any utility can receive to the number necessary to offset any increased electricity costs to such company's retail ratepayers, "including increased cost attributable to purchase power costs" due to the bill (see page 663). But I note that with regard to a similar provision in the Waxman-Markey bill, EPA concluded that "the provision would be very difficult to implement because it

would require a great deal of speculation. First, the Administrator would need to determine (either through projection before the year for which allowances are distributed or through actual data after the year for which allowances are distributed) the total cost of the electricity distributed to its customers each year starting with 2012. Second, the Administrator would need to estimate (again either up front or after the year of the allowance distribution) what each LDC's total cost of electricity would be each year in the absence of the ACES GHG cap and trade program. Total electricity costs would depend on a number of factors that would have to be projected, including the sources and amounts of purchased power, the mix of generation of purchased and LDC generated power, fuel costs, technology advancements (e.g., in generation), transmission constraints, and electricity demand. Any attempt to remove the impact of the cap and trade program on these factors and thus on total electricity costs would be speculative at best. The Administrator might also have to consider the ability of each LDC to pass through these costs to its customers. The difference between these two total cost figures for a given year, divided by the market value of an allowance for that year, would be the limitation on the amount of allowances that an LDC could be distributed for that year. The limitation could be implemented by limiting up front the distribution or by requiring the LDC to return later to the Administrator any amount of allowances in excess of the limitation. The excess allowances would be redistributed to other LDCs, but an iterative process would be required to ensure that the redistribution of excess allowances would not increase any LDC's total allowance distribution above that LDC's limitation. EPA notes that the prohibition provision could reward higher costs to LDC retail ratepayers in that the higher the level of an LDC's costs, the higher the limitation on the LDC's allowance distribution."

Answer:
I would agree with the EPA's conclusion that this provision could be very speculative. Considering the number of factors that would need to be projected with the combined uncertainty of each of those factors, the EPA's determinations would have margins of error large enough to make them quite subjective.

3. Isn't this "Prohibition Against Excess Distributions" provision in the Boxer bill empty and useless since it rally creates no basis for effectively limiting unearned and unfair windfalls to some utilities that simultaneously deprive other utilities who need the allowances of rate impact relief?

   Answer:
   Although I'm not thoroughly familiar with this clause, the EPA's analysis does not make me confident that it does anything to prohibit excess distributions.

4. Isn't this "Prohibition Against Excess Distributions" a fraud since it effectively has no standard to limit the number of allowances a utility may get?

   Answer:
   Again, although not thoroughly familiar with the clause, the EPA's analysis seems to show that it will not do much to prohibit excess distributions.

Senator BOXER. Thank you very much, Mr. Johnson.

I am going to start with you because you said a few things that I want to correct in the record. You talked about being a champion of consumers. I am so proud of you for that, because I am considered a champion of consumers. I got the award from the Consumer Federation of America a while back, and I am very proud of that.

So, let us talk about that because I would not support a bill that was not fair to consumers. Do you know what percentage of the allowances go to protecting consumers in the Kerry-Boxer bill?

Mr. JOHNSON. Well, I have seen different numbers. But I think your central point, Madam Chairman, is absolutely right. A lot of the allocation revenue does go——

Senator BOXER. Do you know the percent I am talking about?

Mr. JOHNSON. I do not, Madam.

Senator BOXER. OK. It is 70 percent. OK. So, first thing is that we are in agreement. Now, it may be at the end of the day it needs to be higher to meet your needs. But I do want to make that point that, and Senator Klobuchar has been very, she is not here now but I want to give her a shout out because she really worked hard on that piece, and that is why at the end of the day the costs for an average American family is 30 cents a day.

Now, you also talked about, and I could not agree with your more, you do not want people to be dependent on the Federal Government. Do you want people to be dependent on foreign oil? I doubt it. That is a patriotic issue, too.

So, I think the issue is, how do we do this in the right way where we become energy independent, create jobs for our people, and keep consumers whole? I think we share those goals.

Now, I want to work with you and your Senators to make sure that this bill meets those standards for your State. But I have to say, you know, some of the things you said about a hit on the economy of 3 percent is not correct. We even do better than the House bill. The House bill, the analysis is one-quarter of a percent in 2020. And at the end of the day, there will be 250 percent larger economy when we get to 2050 instead of a 251 percent. And that does not include any of the unforeseen costs that could come. For example, if we just had one Katrina a year, that is $100 billion.

So I think what we need to do, all of us, is to step back from this and say, what is best for our country? You and I agree on so many principles. We have got to take care of consumers, we have to make sure they are treated fairly, we want to create jobs and we want to make sure that people can get what they need.

And that is the whole purpose of our bill. I guess what I want to ask the rest of the panel is, the minority witnesses are, you know, very concerned about the impact of this on consumers and on the economy. I wonder if any of you can sort of repackage your enthusiastic statements, because I think it is sort of a gloom and doom, frightened of the future type of picture that I get over there, so different than the picture that I got from Mr. Izzo, Mr. Law and Mr. Crane. So, whoever would like to take the time.

Mr. CRANE. Thank you, Madam Chairman. What I would just add on——

Senator BOXER. Where are you headquartered? I did not ask.

Mr. CRANE. Princeton, New Jersey.

Senator BOXER. OK.

Mr. CRANE. I would just add two points. First of all, since we started studying the impact of various sort of cap and trade regimes on the economy, I have seen so many different studies, you know, linear model progressions and the like, and they all come out with extremely different answers. We see them from the Government, we see them within U.S. cap, we have done studies of our own. And I would just add two points to the comments you made.

First, the one thing that has been common to all studies is what you assume about how many nuclear power plants and how much success we have in deploying clean coal has a huge impact on the outcome, particularly in the 2020 to 2040 factor. So that, to me, is a really important part of the overall package.

The second point I would make, Madam Chairman, while I have seen a lot of studies about cap and trade under the House bill, and I am starting to see it on your Senate bill, what we have not seen is what the impact on our economy is going to be if we allow the EPA to act to regulate carbon. And from my perspective, while we are unable to quantify that right now, the consequences of that are very worrisome to our company.

Senator BOXER. Please, Mr. Izzo.

Mr. IZZO. We, too, are worried about customer impacts. We have modeled that, and it looks like our customers under the EPA numbers could see anywhere from a 5 to 6 percent rate increase by 2015. And those are customers who are already probably paying a lot more than other parts of the country which will see a greater percentage increase, but at the end of the day will still be paying a lot less for their electricity.

We never dispute that this legislation will cause an increase in electric rates. By increasing the allocations to consumers, you mitigate against that. We will be cleaning the air, we will be making the world a better place, and we will be investing, and I know of no investment that comes freely, we will be investing in job creation. We say that from experience. We have created those jobs already under the RGGI regime in the——

Senator BOXER. So, in other words, the person, I see South Dakota here under the House bill, the average consumer would pay $5 a month more. That is the average. We think we have made that slightly better. Maybe it is at $4 or $4.50 for your people.

But if that same person gets a job, we anticipate the creation of 2 million jobs, I think that is a very good solution if we go into this clean energy future.

Mr. Law and Mr. Keohane, if you want to add. And then we will go to Senator Inhofe, and I will give him an extra minute for his questions.

Mr. LAW. Yes, Senator, I think that something that people need to distinguish is the difference between rates and bills. There are a lot of things that go into the rates that the utilities have and the goal of the programs, and the legislation, to become smarter with the energy that we use, and more efficient, is to help our customers lower their bills.

So there is not a lot we can do about rates in terms of a lot of our costs are fixed. But we can try to help our customers lower their bills by——

Senator BOXER. By being energy efficient. That is your point.

Mr. LAW. Exactly. Exactly.

Senator BOXER. That is a really important point.

Mr. KEOHANE. I want to build on that point and make a couple of very quick other ones. First, the EPA in its analysis of the House legislation actually estimated savings of household utility bills. Now that reflects, like any modeling result, that reflects the assumption that went into the analysis. But I think the point that makes is that, when you look at the best analysis that is out there, the most careful analysis that is out there, you get a very different picture than what we heard before.

I also want to just repeat, every credible economic analysis, because I have looked at them all, says and shows that we can grow our economy very robustly with a cap on carbon. As you said, Madam Chair, the economy will be much larger in 2020 and 2030 and 2050 than it is today, regardless of what we do. What this is about is protecting our future and making an investment in the future, but it is something that we can absolutely afford.

I wanted to say one more thing in response to what Chairman Johnson said. This cap is exactly what we need to drive the innovation and the development of the investment that he mentioned. We do not need the Government figuring out which projects to devote the money to. We need this system, this market-based system, to figure out how to unleash that innovation.

Senator BOXER. OK, I am going to give Senator Inhofe the extra time I used because I feel it is only fair.

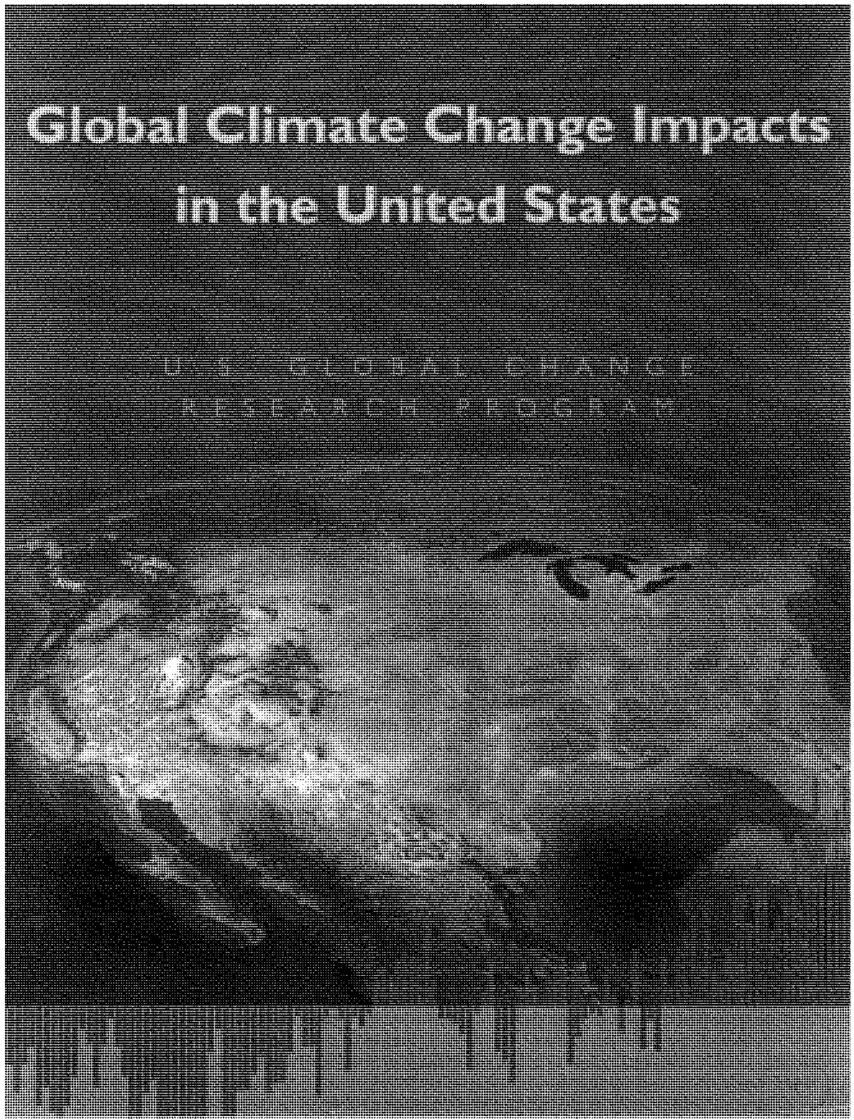
I do want to put in the record for Mr. Johnson and Mr. Hart, here is something about the Great Plains, regional climate impacts on the Great Plains. Think about this in your mind. Projected changes in long-term climate and more frequent extreme events such as heat waves, droughts, heavy rainfall will affect many aspects of life in the Great Plains. These include the region's already threatened water resources, essential agricultural and ranching activities, unique natural and protected areas and the health and prosperity of its inhabitants.

So, here is the point. You take the $5 a month that is the average that people would pay. You put that into that equation. If we can avoid these other disasters from happening, how much better their lives will be. Putting a price on carbon creates the incentives for all these new technologies that you will be carrying.

And you are a young man, you will be carrying these out, the energy efficiency, as Mr. Law pointed out, that you would get. And I think, at the end of the day, it is an exciting story of America stepping out and leading the world, not this frightening let us pull the cover over our heads because we fear the future.

And the more I hear from all of the panelists, they are all excellent, whatever side they are on, whether they are on Senator Inhofe's side or my side, I am coming down to a sense that this is about the future versus the past. I love to take the best parts of the past. I am getting older. I love the past. I loved the 1950s, the 1960s, the 1970s. But at the end of the day, it is my grandkids and your kids, it is their world. I think if we are not fearful, we can do this the right way. But I so appreciate this panel.

[The referenced document follows:]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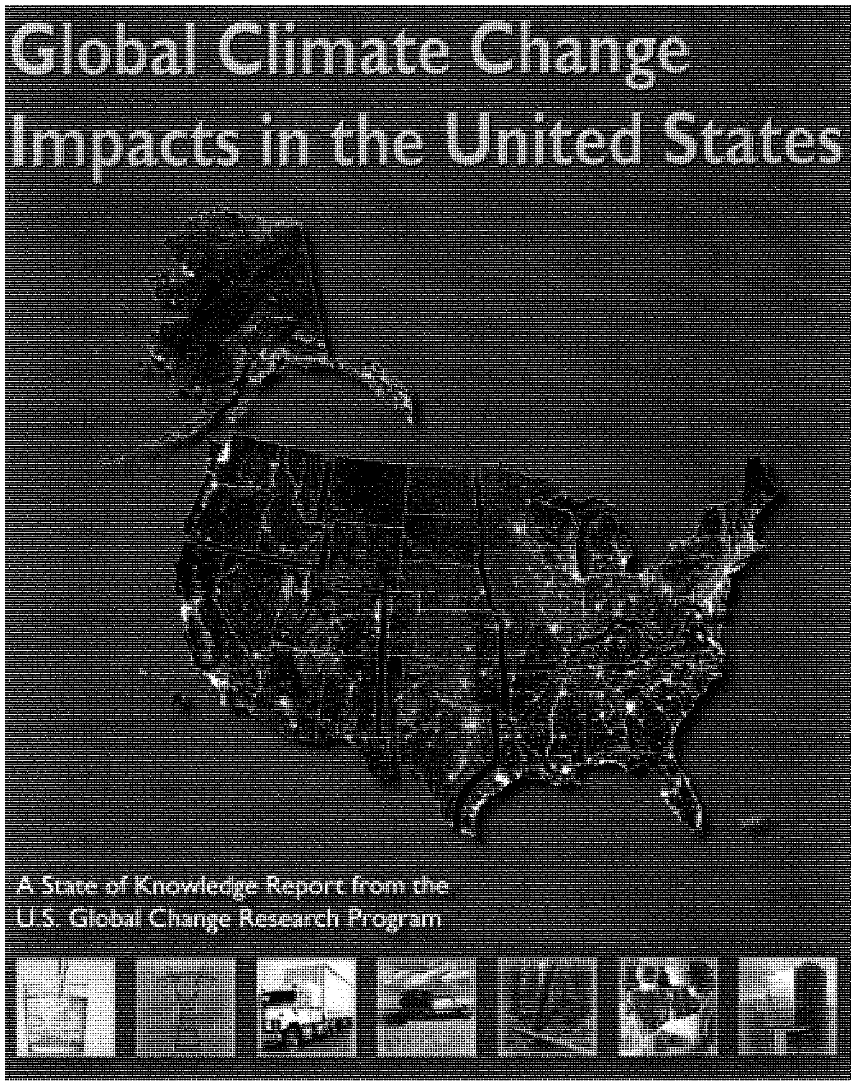
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Impacts in the United States
A State of Knowledge Report from the
U.S. Global Change Research Program

The full report can be found online at www.globalchange.gov/usimpacts

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The bars at the bottom of the front cover show the global annual average temperature from 1900-2008, see page 17.

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This report on Global Climate Change Impacts in the United States was prepared in accordance with Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) and the information quality act guidelines issued by the Department of Commerce and NOAA pursuant to Section 515 <http://www.noaanews.noaa.gov/stories/iq.htm>.

June 2009

Members of Congress:

On behalf of the National Science and Technology Council, the U.S. Global Change Research Program is pleased to transmit to the President and the Congress this state of knowledge report: "*Global Climate Change Impacts in the United States.*" This report summarizes the science of climate change and the impacts of climate change on the United States, now and in the future.

As our nation strives to develop effective policies to respond to climate change, it is critical to have the latest and best scientific information to inform decision making. More than a year in the making, this report provides that information. It is the first report in almost a decade to provide an extensive evaluation of climate change impacts on the United States at the regional level.

An expert team of scientists operating under the authority of the Federal Advisory Committee Act, assisted by communication specialists, wrote the document. The report was reviewed and revised based on comments from experts and the public in accordance with the Information Quality Act guidelines issued by the Department of Commerce and the National Oceanic and Atmospheric Administration.

We highly commend the authors and support personnel of both this report and the underlying Synthesis and Assessment Products for the outstanding quality of their work in providing sound and thorough science-based information for policy formulation and climate change research priority setting. We intend to use the essential information contained in this report as we make policies and decisions about the future, and we recommend others do the same.

Sincerely,

Dr. John Holdren
Director,
Office of Science and Technology Policy

Dr. Jane Luhchenco
Administrator,
National Oceanic and Atmospheric Administration

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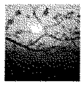

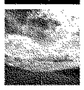

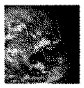

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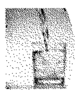

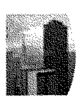

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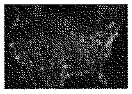

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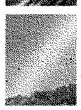


About this Report

What is this report?

This report summarizes the science of climate change and the impacts of climate change on the United States, now and in the future. It is largely based on results of the U.S. Global Change Research Program (USGCRP),[a] and integrates those results with related research from around the world. This report discusses climate-related impacts for various societal and environmental sectors and regions across the nation. It is an authoritative scientific report written in plain language, with the goal of better informing public and private decision making at all levels.

Who called for it, who wrote it, and who approved it?

The USGCRP called for this report. An expert team of scientists operating under the authority of the Federal Advisory Committee Act, assisted by communication specialists, wrote the document. The report was extensively reviewed and revised based on comments from experts and the public. The report was approved by its lead USGCRP Agency, the National Oceanic and Atmospheric Administration, the other USGCRP agencies, and the Committee on the Environment and Natural Resources on behalf of the National Science and Technology Council.[b] This report meets all Federal requirements associated with the Information Quality Act, including those pertaining to public comment and transparency.

What are its sources?

The report draws from a large body of scientific information. The foundation of this report is a set of 21 Synthesis and Assessment Products (SAPs), which were designed to address key policy-relevant issues in climate science (see page 161); several of these were also summarized in the *Scientific Assessment of the Effects of Climate Change on the United States* published in 2008. In addition, other peer-reviewed scientific assessments were used, including those of the Intergovernmental Panel on Climate Change, the U.S. National Assessment of the Consequences of Climate Variability and Change, the Arctic Climate Impact Assessment, the National Research Council's Transportation Research Board report on the Potential Impacts of Climate Change on U.S. Transportation, and a variety of regional climate impact assessments. These assessments were augmented with government statistics as necessary (such as population census and energy usage) as well as publicly available observations and peer-reviewed research published through the end of 2008. This new work was carefully selected by the author team with advice from expert reviewers to update key aspects of climate change science relevant to this report. The icons on the bottom of this page represent some of the major sources drawn upon for this synthesis report.

On the first page of each major section, the sources primarily drawn upon for that section are shown using these icons. Endnotes, indicated by superscript numbers and compiled at the end of the book, are used for specific references throughout the report.

See page 161 for descriptions of these sources.

[a] The U.S. Global Change Research Program (USGCRP), which was established in 1990 by the Global Change Research Act, encompasses the Climate Change Science Program (CCSP).

[b] A description of the National Science and Technology Council (NSTC) can be found at www.ostp.gov/cs/nstc.

Does this report deal with options for responding to climate change?

While the primary focus of this report is on the impacts of climate change in the United States, it also deals with some of the actions society is already taking or can take to respond to the climate challenge. Responses to climate change fall into two broad categories. The first involves "mitigation" measures to reduce climate change by, for example, reducing emissions of heat-trapping gases and particles, or increasing removal of heat-trapping gases from the atmosphere. The second involves "adaptation" measures to improve our ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. Both of these are necessary elements of an effective response strategy. These two types of responses are linked in that more effective mitigation measures reduce the amount of climate change, and therefore the need for adaptation.

This report underscores the importance of mitigation by comparing impacts resulting from bigher versus lower emissions scenarios. The report shows that choices made about emissions in the next few decades will have far-reaching consequences for climate change impacts. Over the long term, lower emissions will lessen both the magnitude of climate change impacts and the rate at which they appear.

While the report underscores the importance of mitigation as an essential part of the nation's climate change strategy, it does not evaluate mitigation technologies or undertake an analysis of the effectiveness of various approaches. These issues are the subject of ongoing studies by the U.S. Government's Climate Change Technology Program and several federal agencies including the Department of Energy, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Department of Transportation, and Department of Agriculture. The range of mitigation responses being studied includes more efficient production and use of energy, increased use of non-carbon-emitting energy sources, and carbon capture and storage.

Adaptation options also have the potential to moderate harmful impacts of current and future climate variability and change. While this report does address adaptation, it does not do so comprehensively. Rather, in the context of impacts, this report identifies examples of actions currently being pursued in various sectors and regions to address climate change, as well as other environmental problems that could be exacerbated by climate change such as urban air pollution and heat waves. In most cases, there is currently insufficient peer-reviewed information to evaluate the practicality, effectiveness, costs, or benefits of these measures, highlighting a need for research in this area. Thus, the discussion of various public and private adaptation examples should not be viewed as an endorsement of any particular option, but rather as illustrative examples of approaches being tried.

How is the likelihood of various outcomes expressed given that the future is not certain?

When it is considered necessary to express a range of possible outcomes and identify the likelihood of particular impacts, this report takes a plain-language approach to expressing the expert judgment of the author team based on the best available evidence. For example, an outcome termed "likely" has at least a two-thirds chance of occurring; an outcome termed "very likely," at least a 90 percent chance.[1] In using these terms, the Federal Advisory Committee has taken into consideration a wide range of information, including the strength and consistency of the observed evidence, the range and consistency of model projections, the reliability of particular models as tested by various methods, and most importantly, the body of work addressed in earlier synthesis and assessment reports. Key sources of information used to develop these characterizations of uncertainty are referenced in endnotes.

How does this report address incomplete scientific understanding?

This assessment identifies areas in which scientific uncertainty limits our ability to estimate future climate change and its impacts. The section on *An Agenda for Climate Impacts Science* at the end of this report highlights some of these areas.

Executive Summary

Observations show that warming of the climate is unequivocal. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. These emissions come mainly from the burning of fossil fuels (coal, oil, and gas), with important contributions from the clearing of forests, agricultural practices, and other activities.

Warming over this century is projected to be considerably greater than over the last century. The global average temperature since 1900 has risen by about 1.5°F. By 2100, it is projected to rise another 2 to 11.5°F. The U.S. average temperature has risen by a comparable amount and is very likely to rise more than the global average over this century, with some variation from place to place. Several factors will determine future temperature increases. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are cut substantially. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range. Volcanic eruptions or other natural variations could temporarily counteract some of the human-induced warming, slowing the rise in global temperature, but these effects would only last a few years.

Reducing emissions of carbon dioxide would lessen warming over this century and beyond. Sizable early cuts in emissions would significantly reduce the pace and the overall amount of climate change. Earlier cuts in emissions would have a greater effect in reducing climate change than comparable reductions made later. In addition, reducing emissions of some shorter-lived heat-trapping gases, such as methane, and some types of particles, such as soot, would begin to reduce warming within weeks to decades.

Climate-related changes have already been observed globally and in the United States. These include increases in air and water temperatures, reduced frost days, increased frequency and intensity of heavy downpours, a rise in sea level, and reduced snow cover, glaciers, permafrost, and sea ice. A longer ice-free period on lakes and rivers, lengthening of the growing season, and increased water vapor in the atmosphere have also been observed. Over the past 30 years, temperatures have risen faster in winter than in any other season, with average winter temperatures in the Midwest and northern Great Plains increasing more than 7°F. Some of the changes have been faster than previous assessments had suggested.

These climate-related changes are expected to continue while new ones develop. Likely future changes for the United States and surrounding coastal waters include more intense hurricanes with related increases in wind, rain, and storm surges (but not necessarily an increase in the number of these storms that make landfall), as well as drier conditions in the Southwest and Caribbean. These changes will affect human health, water supply, agriculture, coastal areas, and many other aspects of society and the natural environment.

This report synthesizes information from a wide variety of scientific assessments (see page 7) and recently published research to summarize what is known about the observed and projected consequences of climate change on the United States. It combines analysis of impacts on various sectors

such as energy, water, and transportation at the national level with an assessment of key impacts on specific regions of the United States. For example, sea-level rise will increase risks of erosion, storm surge damage, and flooding for coastal communities, especially in the Southeast and parts of Alaska. Reduced snowpack and earlier snow melt will alter the timing and amount of water supplies, posing significant challenges for water resource management in the West.

Society and ecosystems can adjust to some climatic changes, but this takes time. The projected rapid rate and large amount of climate change over this century will challenge the ability of society and natural systems to adapt. For example, it is difficult and expensive to alter or replace infrastructure designed to last for decades (such as buildings, bridges, roads, airports, reservoirs, and ports) in response to continuous and/or abrupt climate change.

Impacts are expected to become increasingly severe for more people and places as the amount of warming increases. Rapid rates of warming would lead to particularly large impacts on natural ecosystems and the benefits they provide to humanity. Some of the impacts of climate change will be irreversible, such as species extinctions and coastal land lost to rising seas.

Unanticipated impacts of increasing carbon dioxide and climate change have already occurred and more are possible in the future. For example, it has recently been observed that the increase in atmospheric carbon dioxide concentration is causing an increase in ocean acidity. This reduces the ability of corals and other sea life to build shells and skeletons out of calcium carbonate. Additional impacts in the future might stem from unforeseen changes in the climate system, such as major alterations in oceans, ice, or storms; and unexpected consequences of ecological changes, such as massive dislocations of species or pest outbreaks. Unexpected social or economic changes, including major shifts in wealth, technology, or societal priorities would also affect our ability to respond to climate change. Both anticipated and unanticipated impacts become more challenging with increased warming.

Projections of future climate change come from careful analyses of outputs from global climate models run on the world's most advanced computers. The model simulations analyzed in this report used plausible scenarios of human activity that generally lead to further increases in heat-trapping emissions. None of the scenarios used in this report assumes adoption of policies explicitly designed to address climate change. However, the level of emissions varies among scenarios because of differences in assumptions about population, economic activity, choice of energy technologies, and other factors. Scenarios cover a range of emissions of heat-trapping gases, and the associated climate projections illustrate that lower emissions result in less climate change and thus reduced impacts over this century and beyond. Under all scenarios considered in this report, however, relatively large and sustained changes in many aspects of climate are projected by the middle of this century, with even larger changes by the end of this century, especially under higher emissions scenarios.

In projecting future conditions, there is always some level of uncertainty. For example, there is a high degree of confidence in projections that future temperature increases will be greatest in the Arctic and in the middle of continents. For precipitation, there is high confidence in projections of continued increases in the Arctic and sub-Arctic (including Alaska) and decreases in the regions just outside the tropics, but the precise location of the transition between these is less certain. At local to regional scales and on time frames up to a few years, natural climate variations can be relatively large and can temporarily mask the progressive nature of global climate change. However, the science of making skillful projections at these scales has progressed considerably, allowing useful information to be drawn from regional climate studies such as those highlighted in this report.

This report focuses on observed and projected climate change and its impacts on the United States. However, a discussion of these issues would be incomplete without mentioning some of the actions society can take to respond to the climate challenge. The two major categories are "mitigation" and "adaptation." Mitigation refers to options for limiting climate change by, for example, reducing

heat-trapping emissions such as carbon dioxide, methane, nitrous oxide, and halocarbons, or removing some of the heat-trapping gases from the atmosphere. Adaptation refers to changes made to better respond to present or future climatic and other environmental conditions, thereby reducing harm or taking advantage of opportunity. Effective mitigation measures reduce the need for adaptation. Mitigation and adaptation are both essential parts of a comprehensive climate change response strategy.

Carbon dioxide emissions are a primary focus of mitigation strategies. These include improving energy efficiency, using energy sources that do not produce carbon dioxide or produce less of it, capturing and storing carbon dioxide from fossil fuel use, and so on. Choices made about emissions reductions now and over the next few decades will have far-reaching consequences for climate-change impacts. The importance of mitigation is clear in comparisons of impacts resulting from higher versus lower emissions scenarios considered in this report. Over the long term, lower emissions will lessen both the magnitude of climate-change impacts and the rate at which they appear. Smaller climate changes that come more slowly make the adaptation challenge more tractable.

However, no matter how aggressively heat-trapping emissions are reduced, some amount of climate change and resulting impacts will continue due to the effects of gases that have already been released. This is true for several reasons. First, some of these gases are very long-lived and the levels of atmospheric heat-trapping gases will remain elevated for hundreds of years or more. Second, the Earth's vast oceans have absorbed much of the heat added to the climate system due to the increase in heat-trapping gases, and will retain that heat for many decades. In addition, the factors that determine emissions, such as energy-supply systems, cannot be changed overnight. Consequently, there is also a need for adaptation.

Adaptation can include a wide range of activities. Examples include a farmer switching to growing a different crop variety better suited to warmer or drier conditions; a company relocating key business centers away from coastal areas vulnerable to sea-level rise and hurricanes; and a community altering its zoning and building codes to place fewer structures in harm's way and making buildings less vulnerable to damage from floods, fires, and other extreme events. Some adaptation options that are currently being pursued in various regions and sectors to deal with climate change and/or other environmental issues are identified in this report. However, it is clear that there are limits to how much adaptation can achieve.

Humans have adapted to changing climatic conditions in the past, but in the future, adaptations will be particularly challenging because society won't be adapting to a new steady state but rather to a rapidly moving target. Climate will be continually changing, moving at a relatively rapid rate, outside the range to which society has adapted in the past. The precise amounts and timing of these changes will not be known with certainty.

In an increasingly interdependent world, U.S. vulnerability to climate change is linked to the fates of other nations. For example, conflicts or mass migrations of people resulting from food scarcity and other resource limits, health impacts, or environmental stresses in other parts of the world could threaten U.S. national security. It is thus difficult to fully evaluate the impacts of climate change on the United States without considering the consequences of climate change elsewhere. However, such analysis is beyond the scope of this report.

Finally, this report identifies a number of areas in which inadequate information or understanding hampers our ability to estimate future climate change and its impacts. For example, our knowledge of changes in tornadoes, hail, and ice storms is quite limited, making it difficult to know if and how such events have changed as climate has warmed, and how they might change in the future. Research on ecological responses to climate change is also limited, as is our understanding of social responses. The section titled *An Agenda for Climate Impacts Science* at the end of this report offers some thoughts on the most important ways to improve our knowledge. Results from such efforts would inform future assessments that continue building our understanding of humanity's impacts on climate, and climate's impacts on us.

Key Findings

1. Global warming is unequivocal and primarily human-induced.
Global temperature has increased over the past 50 years. This observed increase is due primarily to human-induced emissions of heat-trapping gases. (p. 13)

2. Climate changes are underway in the United States and are projected to grow.
Climate-related changes are already observed in the United States and its coastal waters. These include increases in heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. These changes are projected to grow. (p. 27)

3. Widespread climate-related impacts are occurring now and are expected to increase.
Climate changes are already affecting water, energy, transportation, agriculture, ecosystems, and health. These impacts are different from region to region and will grow under projected climate change. (p. 41-106, 107-152)

4. Climate change will stress water resources.
Water is an issue in every region, but the nature of the potential impacts varies. Drought, related to reduced precipitation, increased evaporation, and increased water loss from plants, is an important issue in many regions, especially in the West. Floods and water quality problems are likely to be amplified by climate change in most regions. Declines in mountain snowpack are important in the West and Alaska where snowpack provides vital natural water storage. (p. 41, 129, 135, 139)

5. Crop and livestock production will be increasingly challenged.
Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields. Increased pests, water stress, diseases, and weather extremes will pose adaptation challenges for crop and livestock production. (p. 71)

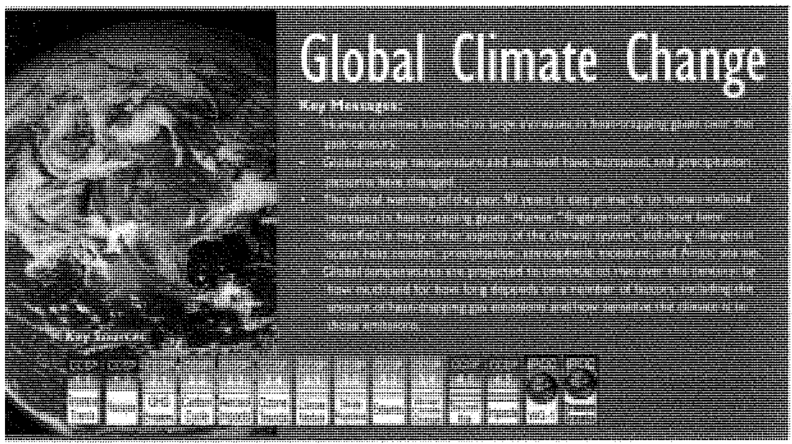
6. Coastal areas are at increasing risk from sea-level rise and storm surge.
Sea-level rise and storm surge place many U.S. coastal areas at increasing risk of erosion and flooding, especially along the Atlantic and Gulf Coasts, Pacific Islands, and parts of Alaska. Energy and transportation infrastructure and other property in coastal areas are very likely to be adversely affected. (p. 111, 139, 145, 149)

7. Risks to human health will increase.
Harmful health impacts of climate change are related to increasing heat stress, waterborne diseases, poor air quality, extreme weather events, and diseases transmitted by insects and rodents. Reduced cold stress provides some benefits. Robust public health infrastructure can reduce the potential for negative impacts. (p. 89)

8. Climate change will interact with many social and environmental stresses.
Climate change will combine with pollution, population growth, overuse of resources, urbanization, and other social, economic, and environmental stresses to create larger impacts than from any of these factors alone. (p. 99)

9. Thresholds will be crossed, leading to large changes in climate and ecosystems.
There are a variety of thresholds in the climate system and ecosystems. These thresholds determine, for example, the presence of sea ice and permafrost, and the survival of species, from fish to insect pests, with implications for society. With further climate change, the crossing of additional thresholds is expected. (p. 76, 82, 115, 137, 142)

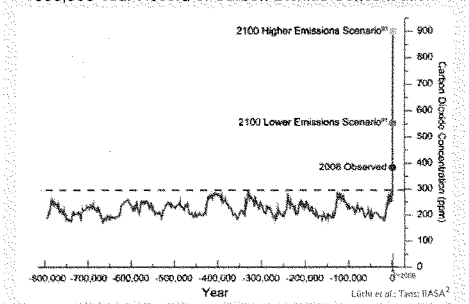
10. Future climate change and its impacts depend on choices made today.
The amount and rate of future climate change depend primarily on current and future human-caused emissions of heat-trapping gases and airborne particles. Responses involve reducing emissions to limit future warming, and adapting to the changes that are unavoidable. (p. 25, 29)



This introduction to global climate change explains very briefly what has been happening to the world's climate and why, and what is projected to happen in the future. While this report focuses on climate change impacts in the United States, understanding these changes and their impacts requires an understanding of the global climate system.

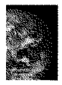
Many changes have been observed in global climate over the past century. The nature and causes of these changes have been comprehensively chronicled in a variety of recent reports, such as those by the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Climate Change Science Program (CCSP). This section does not intend to duplicate these comprehensive efforts, but rather to provide a brief synthesis, and to integrate more recent work with the assessments of the IPCC, CCSP, and others.

800,000 Year Record of Carbon Dioxide Concentration



Lüthi et al.; Tans; IIASA[2]

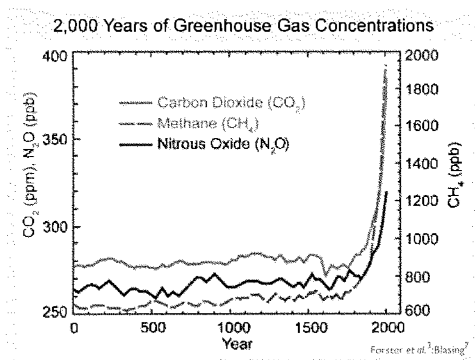
Analysis of air bubbles trapped in an Antarctic ice core extending back 800,000 years documents the Earth's changing carbon dioxide concentration. Over this long period, natural factors have caused the atmospheric carbon dioxide concentration to vary within a range of about 170 to 300 parts per million (ppm). Temperature-related data make clear that these variations have played a central role in determining the global climate. As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years. In the absence of strong control measures, emissions projected for this century would result in the carbon dioxide concentration increasing to a level that is roughly 2 to 3 times the highest level occurring over the glacial-interglacial era that spans the last 800,000 or more years.



Human activities have led to large increases in heat-trapping gases over the past century.

The Earth's climate depends on the functioning of a natural "greenhouse effect." This effect is the result of heat-trapping gases (also known as greenhouse gases) like water vapor, carbon dioxide, ozone, methane, and nitrous oxide, which absorb heat radiated from the Earth's surface and lower atmosphere and then radiate much of the energy back toward the surface. Without this natural greenhouse effect, the average surface temperature of the Earth would be about 60°F colder. However, human activities have been releasing additional heat-trapping gases, intensifying the natural greenhouse effect, thereby changing the Earth's climate.

Climate is influenced by a variety of factors, both human-induced and natural. The increase in the carbon dioxide concentration has been the principal factor causing warming over the past 50 years. Its concentration has been building up in the Earth's atmosphere since the beginning of the industrial era in the mid-1700s, primarily due to the burning of fossil fuels (coal, oil, and natural gas) and the clearing of forests. Human activities have also increased the emissions of other greenhouse gases, such as methane, nitrous oxide, and halocarbons.[3]



Increases in concentrations of these gases since 1750 are due to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.

These emissions are thickening the blanket of heat-trapping gases in Earth's atmosphere, causing surface temperatures to rise.

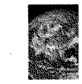
Heat-trapping gases

Carbon dioxide concentration has increased due to the use of fossil fuels in electricity generation, transportation, and industrial and household uses. It is also produced as a by-product during the manufacturing of cement. Deforestation provides a source of carbon dioxide and reduces its uptake by trees and other plants. Globally, over the past several decades, about 80 percent of human-induced carbon dioxide emissions came from the burning of fossil fuels, while about 20 percent resulted from deforestation and associated agricultural practices. The concentration of carbon dioxide in the atmosphere has increased by roughly 35 percent since the start of the industrial revolution.[3]

Methane concentration has increased mainly as a result of agriculture; raising livestock (which produce methane in their digestive tracts); mining, transportation, and use of certain fossil fuels; sewage; and decomposing garbage in landfills. About 70 percent of the emissions of atmospheric methane are now related to human activities.[4]

Nitrous oxide concentration is increasing as a result of fertilizer use and fossil fuel burning.

Halocarbon emissions come from the release of certain manufactured chemicals to the atmosphere. Examples include chlorofluorocarbons (CFCs), which were used extensively in refrigeration and for other industrial processes before their presence in the atmosphere was found to cause stratospheric ozone depletion. The abundance of these gases in the atmosphere is now decreasing as a result of international regulations designed to protect the ozone layer. Continued decreases in ozone-depleting halocarbon emissions are expected to reduce their relative influence on climate change in the future.[3,5] Many halocarbon replacements, however, are potent greenhouse gases, and their concentrations are increasing.[6]



Ozone is a greenhouse gas, and is continually produced and destroyed in the atmosphere by chemical reactions. In the troposphere, the lowest 5 to 10 miles of the atmosphere near the surface, human activities have increased the ozone concentration through the release of gases such as carbon monoxide, hydrocarbons, and nitrogen oxides. These gases undergo chemical reactions to produce ozone in the presence of sunlight. In addition to trapping heat, excess ozone in the troposphere causes respiratory illnesses and other human health problems.

In the stratosphere, the layer above the troposphere, ozone exists naturally and protects life on Earth from exposure to excessive ultraviolet radiation from the Sun. As mentioned previously, halocarbons released by human activities destroy ozone in the stratosphere and have caused the ozone hole over Antarctica.[8] Changes in the stratospheric ozone layer have contributed to changes in wind patterns and regional climates in Antarctica.[9]

Water vapor is the most important and abundant greenhouse gas in the atmosphere. Human activities produce only a very small increase in water vapor through irrigation and combustion processes.[3] However, the surface warming caused by human-produced increases in other greenhouse gases leads to an increase in atmospheric water vapor, since a warmer climate increases evaporation and allows the atmosphere to hold more moisture. This creates an amplifying "feedback loop," leading to more warming.

Other human influences

In addition to the global-scale climate effects of heat-trapping gases, human activities also produce additional local and regional effects. Some of these activities partially offset the warming caused by greenhouse gases, while others increase the warming. One such influence on climate is caused by tiny particles called "aerosols" (not to be confused with aerosol spray cans). For example, the burning of coal produces emissions of sulfur-containing compounds. These compounds form "sulfate aerosol" particles, which reflect some of the incoming sunlight away from the Earth, causing a cooling influence at the surface. Sulfate aerosols also tend to make clouds more efficient at reflecting sunlight, causing an additional indirect cooling effect. Another type of aerosol, often referred to as soot or black carbon, absorbs incoming sunlight and traps heat in the atmosphere. Thus, depending on their type, aerosols can either mask or increase the warming caused by increased levels of greenhouse gases.[13] On a globally averaged basis, the sum of these aerosol effects offsets some of the warming caused by heat-trapping gases.[10]

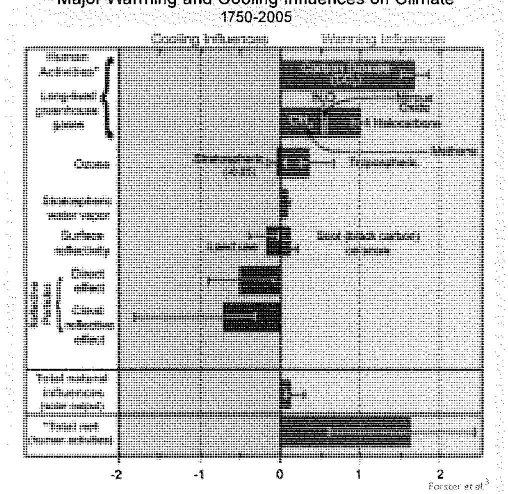
The effects of various greenhouse gases and aerosol particles on Earth's climate depend in part on how long these gases and particles remain in the atmosphere. After emission, the atmospheric concentration of carbon dioxide remains elevated for thousands of years, and that of methane for decades, while the elevated concentrations of aerosols only persist for days to weeks.[11,12] The climate effects of reductions in emissions of carbon dioxide and other long-lived gases do not become apparent for at least several decades. In contrast, reductions in emissions of short-lived compounds can have a rapid, but complex effect since the geographic patterns of their climatic influence and the resulting surface temperature responses are quite different. One modeling study found that while the greatest emissions of short-lived pollutants in summertime by late this century are projected to come from Asia, the strongest climate response is projected to be over the central United States.[13]

Human activities have also changed the land surface in ways that alter how much heat is reflected or absorbed by the surface. Such changes include the cutting and burning of forests, the replacement of other areas of natural vegetation with agriculture and cities, and large-scale irrigation. These transformations of the land surface can cause local (and even regional) warming or cooling. Globally, the net effect of these changes has probably been a slight cooling of the Earth's surface over the past 100 years.[14,15]

Natural influences

Two important natural factors also influence climate: the Sun and volcanic eruptions. Over the past three decades, human influences on climate have become increasingly obvious, and global temperatures have risen sharply. During the same period, the Sun's energy output (as measured by satellites since 1979) has followed its historical 11-year cycle of small ups and downs, but with no net increase (see figure page 20).[16] The two major volcanic eruptions of the past 30 years have had short-term cooling effects on climate, lasting 2 to 3 years.[17] Thus, these natural factors cannot explain the warming of recent decades; in fact, their net effect on climate has probably been a slight cooling influence over this period. Slow changes in Earth's orbit around the Sun and its tilt toward or away from the Sun are also a purely natural influence on climate, but are only important on timescales from thousands to many tens of thousands of years.

The climate changes that have occurred over the last century are not solely caused by the human and natural factors described above. In addition to these influences, there are also fluctuations in climate that occur even in the absence of changes in human activities, the Sun, or volcanoes. One example is the El Niño phenomenon, which has important influences on many aspects of regional and global climate. Many other modes of variability have been identified by climate scientists and their effects on climate occur at the same time as the effects of human activities, the Sun, and volcanoes.



The figure above shows the amount of warming influence (red bars) or cooling influence (blue bars) that different factors have had on Earth's climate over the industrial age (from about 1750 to the present). Results are in watts per square meter. The longer the bar, the greater the influence on climate. The top part of the box includes all the major human-induced factors, while the second part of the box includes the Sun, the only major natural factor with a long-term effect on climate. The cooling effect of individual volcanoes is also natural, but is relatively short-lived (2 to 3 years), thus their influence is not included in this figure. The bottom part of the box shows that the total net effect (warming influences minus cooling influences) of human activities is a strong warming influence. The thin lines on each bar provide an estimate of the range of uncertainty.

Carbon release and uptake

Once carbon dioxide is emitted to the atmosphere, some of it is absorbed by the oceans and taken up by vegetation, although this storage may be temporary. About 45 percent of the carbon dioxide emitted by human activities in the last 50 years is now stored in the oceans and vegetation. The rest has remained in the air, increasing the atmospheric concentration.[2,3,18] It is thus important to understand not only how much carbon dioxide is emitted, but also how much is taken up, over what time scales, and how these sources and "sinks" of carbon dioxide might change as climate continues to warm. For example, it is known from long records of Earth's climate history that under warmer conditions, carbon tends to be released, for instance, from thawing permafrost, initiating a feedback loop in which more carbon release leads to more warming which leads to further release, and so on.[19,20]

Global emissions of carbon dioxide have been accelerating. The growth rate increased from 1.3 percent per year in the 1990s to 3.3 percent per year between 2000 and 2006.[21] The increasing emissions of carbon dioxide are the primary cause of the increased concentration of carbon dioxide observed in the atmosphere. There is also evidence that a smaller fraction of the annual human-induced emissions is now being taken up than in the past, leading to a greater fraction remaining in the atmosphere and an accelerating rate of increase in the carbon dioxide concentration.[21]

Ocean acidification

As the ocean absorbs carbon dioxide from the atmosphere, seawater is becoming less alkaline (its pH is decreasing) through a process generally referred to as ocean acidification. The pH of seawater has decreased significantly since 1750,[22,23] and is projected to drop much more dramatically by the end of the century if carbon dioxide concentrations continue to increase.[24] Such ocean acidification is essentially irreversible over a time scale of centuries. As discussed in the *Ecosystems* sector and *Coasts* region, ocean acidification affects the process of calcification by which living things create shells and skeletons, with substantial negative consequences for coral reefs, mollusks, and some plankton species important to ocean food chains.[25]

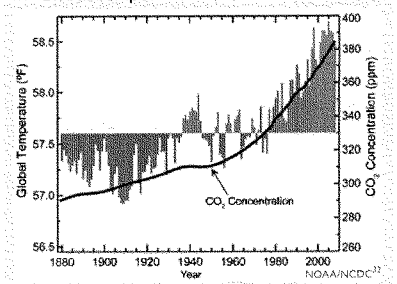
Global average temperature and sea level have increased, and precipitation patterns have changed.

Temperatures are rising

Global average surface air temperature has increased substantially since 1970.[26] The estimated change in the average temperature of Earth's surface is based on measurements from thousands of weather stations, ships, and buoys around the world, as well as from satellites. These measurements are independently compiled, analyzed, and processed by different research groups. There are a number of important steps in the data processing. These include identifying and adjusting for the effects of changes in the instruments used to measure temperature, the measurement times and locations, the local environment around the measuring site, and such factors as satellite orbital drift. For instance, the growth of cities can cause localized "urban heat island" effects.

A number of research groups around the world have produced estimates of global-scale changes in surface temperature. The warming trend that is apparent in all of these temperature records is confirmed by other independent observations, such as the melting of Arctic sea ice, the retreat of mountain glaciers on every continent,[27] reductions in the extent of snow cover, earlier blooming of plants in spring, and increased melting of the Greenland and Antarctic ice sheets.[28,29] Because snow and ice

Global Temperature and Carbon Dioxide



NOAA/NCDC[32]

Global annual average temperature (as measured over both land and oceans). Red bars indicate temperatures above and blue bars indicate temperatures below the average temperature for the period 1901-2000. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). While there is a clear long-term global warming trend, each individual year does not show a temperature increase relative to the previous year, and some years show greater changes than others.[33] These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and the eruption of large volcanoes.

reflect the Sun's heat, this melting causes more heat to be absorbed, which causes more melting, resulting in another feedback loop.[20]

Additionally, temperature measurements above the surface have been made by weather balloons since the late 1940s, and from satellites since 1979. These measurements show warming of the troposphere, consistent with the surface warming.[30,31] They also reveal cooling in the stratosphere.[30] This pattern of tropospheric warming and stratospheric cooling agrees with our understanding of how atmospheric temperature would be expected to change in response to increasing greenhouse gas concentrations and the observed depletion of stratospheric ozone.[14]

Precipitation patterns are changing

Precipitation is not distributed evenly over the globe. Its average distribution is governed primarily by atmospheric circulation patterns, the availability of moisture, and surface terrain effects. The first two of these factors are influenced by temperature. Thus, human-caused changes in temperature are expected to alter precipitation patterns.

Observations show that such shifts are occurring. Changes have been observed in the amount, intensity, frequency, and type of precipitation. Pronounced increases in precipitation over the past 100 years have been observed in eastern North America, southern South America, and northern Europe. Decreases have been seen in the Mediterranean, most of Africa, and southern Asia. Changes in the geographical distribution of droughts and flooding have been complex. In some regions, there have been increases in the occurrences of both droughts and floods.[28] As the world warms, northern regions and mountainous areas are experiencing more precipitation falling as rain rather than snow.[34] Widespread increases in heavy precipitation events have occurred, even in places where total rain amounts have decreased. These changes are associated with the fact that warmer air holds more water vapor evaporating from the world's oceans and land surface.[31] This increase in atmospheric water vapor has been observed from satellites, and is primarily due to human influences.[35,36]

Sea level is rising

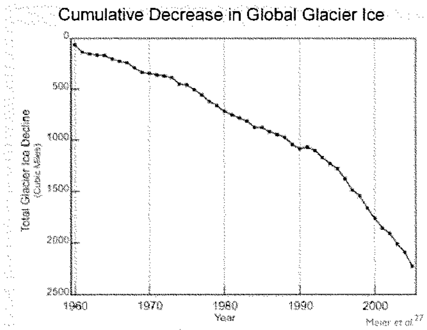
After at least 2,000 years of little change, sea level rose by roughly 8 inches over the past century. Satellite data available over the past 15 years show sea level rising at a rate roughly double the rate observed over the past century.[37]

There are two principal ways in which global warming causes sea level to rise. First, ocean water expands as it warms, and therefore takes up more space. Warming has been observed in each of the world's major ocean basins, and has been directly linked to human influences.[38,39]

Second, warming leads to the melting of glaciers and ice sheets, which raises sea level by adding water to the oceans. Glaciers have been retreating worldwide for at least the last century, and the rate of retreat has increased in the past decade.[29,40] Only a few glaciers are actually advancing (in locations that were well below freezing, and where increased precipitation has outpaced melting). The total volume of glaciers on Earth is declining sharply. The progressive disappearance of glaciers has implications not only for the rise in global sea level, but also for water supplies in certain densely populated regions of Asia and South America.

The Earth has major ice sheets on Greenland and Antarctica. These ice sheets are currently losing ice volume by increased melting and calving of icebergs, contributing to sea-level rise. The Greenland Ice Sheet has also been experiencing record amounts of surface melting, and a large increase in the rate of mass loss in the past decade.[41] If the entire Greenland Ice Sheet melted, it would raise sea level by about 20 feet. The Antarctic Ice Sheet consists of two portions, the West Antarctic Ice Sheet and the East Antarctic Ice Sheet. The West Antarctic Ice Sheet, the more vulnerable to melting of the two, contains enough water to raise global sea levels by about 16 to 20 feet.[29] If the East Antarctic Ice Sheet melted entirely, it would raise global sea level by about 200 feet. Complete melting of these ice sheets over this century or the next is thought to be virtually impossible, although past climate records provide precedent for very significant decreases in ice volume, and therefore increases in sea level.[42,43]

Cumulative Decrease in Global Glacier Ice



As temperatures have risen, glaciers around the world have shrunk. The graph shows the cumulative decline in glacier ice worldwide.

The global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases. Human "fingerprints" also have been identified in many other aspects of the climate system, including changes in ocean heat content, precipitation, atmospheric moisture, and Arctic sea ice.

In 1996, the IPCC Second Assessment Report[44] cautiously concluded that "the balance of evidence suggests a discernible human influence on global climate." Since then, a number of national and international assessments have come to much stronger conclusions about the reality of human effects on climate. Recent scientific assessments find that most of the warming of the Earth's surface over the past 50 years has been caused by human activities.[45,46]

This conclusion rests on multiple lines of evidence. Like the warming "signal" that has gradually emerged from the "noise" of natural climate variability, the scientific evidence for a human influence on global climate has accumulated over the past several decades, from many hundreds of studies. No single study is a "smoking gun." Nor has any single study or combination of studies undermined the large body of evidence supporting the conclusion that human activity is the primary driver of recent warming.

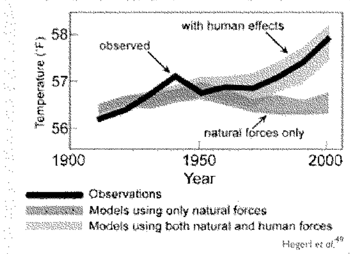
The first line of evidence is our basic physical understanding of how greenhouse gases trap heat, how the climate system responds to increases in greenhouse gases, and how other human and natural factors influence climate. The second line of evidence is from indirect estimates of climate changes over the last 1,000 to 2,000 years. These records are obtained from living things and their remains (like tree rings and corals) and from physical quantities (like the ratio between lighter and heavier isotopes of oxygen in ice cores) which change in measurable ways as climate changes. The lesson from these data is that global surface temperatures over the last several decades are clearly unusual, in that they were higher than at any time during at least the past 400 years.[47] For the Northern Hemisphere, the recent temperature rise is clearly unusual in at least the last 1,000 years.[47,48]

The third line of evidence is based on the broad, qualitative consistency between observed changes in climate and the computer model simulations of how climate would be expected to change in response to human activities. For example, when climate models are run with historical increases in greenhouse gases, they show gradual warming of the Earth and ocean surface, increases in ocean heat content and the temperature of the lower atmosphere, a rise in global sea level, retreat of sea ice and snow cover, cooling of the stratosphere, an increase in the amount of atmospheric water vapor, and changes in large-scale precipitation and pressure patterns. These and other aspects of modeled climate change are in agreement with observations.[14,49]

Finally, there is extensive statistical evidence from so-called "fingerprint" studies. Each factor that affects climate produces a unique pattern of climate response, much as each person has a unique fingerprint. Fingerprint studies exploit these unique signatures, and allow detailed comparisons of modeled and observed climate change patterns.[44] Scientists rely on such studies to attribute observed changes in climate to a particular cause or set of causes. In the real world, the climate changes that have occurred since the start of the Industrial Revolution are due to a complex mixture of human and natural causes. The importance of each individual influence in this mixture changes over time. Of course, there are not multiple Earths, which would allow an experimenter to change one factor at a time on each Earth, thus helping to isolate different fingerprints. Therefore, climate models are used to study how individual factors affect climate. For example, a single factor (like greenhouse gases) or a set of factors can be varied, and the response of the modeled climate system to these individual or combined changes can thus be studied.[50]

For example, when climate model simulations of the last century include all of the major influences on climate, both human-induced and natural, they can reproduce many important features of observed climate change patterns. When human influences are removed from the model experiments, results suggest that the surface of the Earth would actually have cooled slightly over the last 50 years. The clear message from fingerprint studies is that the

Separating Human and Natural Influences on Climate



The blue band shows how global average temperatures would have changed due to natural forces only, as simulated by climate models. The red band shows model projections of the effects of human and natural forces combined. The black line shows actual observed global average temperatures. As the blue band indicates, without human influences, temperature over the past century would actually have first warmed and then cooled slightly over recent decades.[58]

observed warming over the last half-century cannot be explained by natural factors, and is instead caused primarily by human factors.[14,50]

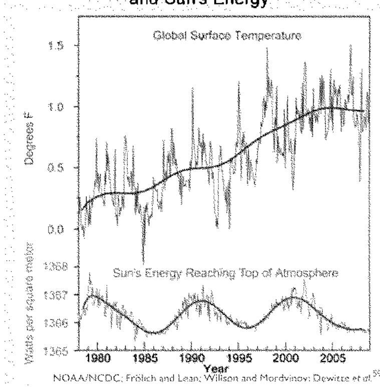
Another fingerprint of human effects on climate has been identified by looking at a slice through the layers of the atmosphere, and studying the pattern of temperature changes from the surface up through the stratosphere. In all climate models, increases in carbon dioxide cause warming at the surface and in the troposphere, but lead to cooling of the stratosphere. For straightforward physical reasons, models also calculate that the human-caused depletion of stratospheric ozone has had a strong cooling effect in the stratosphere. There is a good match between the model fingerprint in response to combined carbon dioxide and ozone changes and the observed pattern of tropospheric warming and stratospheric cooling (see figure on next page).[14]

In contrast, if most of the observed temperature change had been due to an increase in solar output rather than an increase in greenhouse gases, Earth's atmosphere would have warmed throughout its full vertical extent, including the stratosphere.[9] The observed pattern of atmospheric temperature changes, with its pronounced cooling in the stratosphere, is therefore inconsistent with the hypothesis that changes in the Sun can explain the warming of recent decades. Moreover, direct satellite measurements of solar output show slight decreases during the recent period of warming.

The earliest fingerprint work[51] focused on changes in surface and atmospheric temperature. Scientists then applied fingerprint methods to a whole range of climate variables,[50,52] identifying human-caused climate signals in the heat content of the oceans,[38,39] the height of the tropopause[53] (the boundary between the troposphere and stratosphere, which has shifted upward by hundreds of feet in recent decades), the geographical patterns of precipitation,[54] drought,[55] surface pressure,[56] and the runoff from major river basins.[57]

Studies published after the appearance of the IPCC Fourth Assessment Report in 2007 have also found human fingerprints in the increased levels of atmospheric moisture[35,36] (both close to the surface and over the full extent of the atmosphere), in the

Measurements of Surface Temperature and Sun's Energy



The Sun's energy received at the top of Earth's atmosphere has been measured by satellites since 1978. It has followed its natural 11-year cycle of small ups and downs, but with no net increase (bottom). Over the same period, global temperature has risen markedly (top).[60]

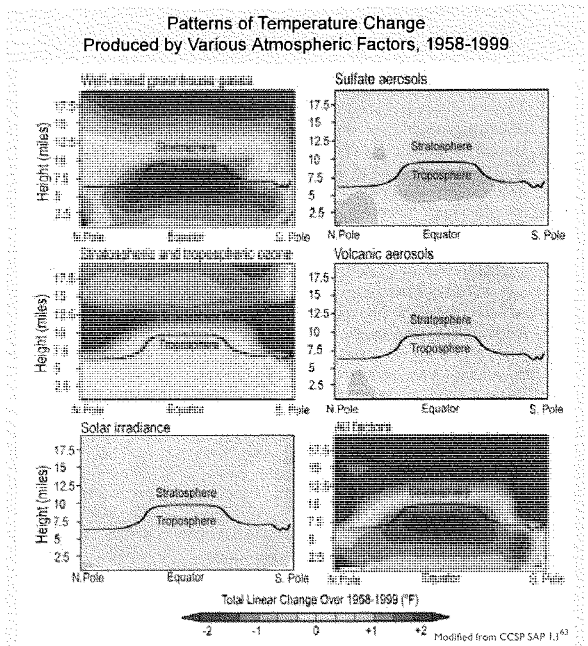
decline of Arctic sea ice extent,[61] and in the patterns of changes in Arctic and Antarctic surface temperatures.[62]

The message from this entire body of work is that the climate system is telling a consistent story of increasingly dominant human influence – the changes in temperature, ice extent, moisture, and circulation patterns fit together in a physically consistent way, like pieces in a complex puzzle.

Increasingly, this type of fingerprint work is shifting its emphasis. As noted, clear and compelling scientific evidence supports the case for a pronounced human influence on global climate. Much of the recent attention is now on climate changes at continental and regional scales,[64,65] and on variables that can have large impacts on societies. For example, scientists have established causal links between human activities and the changes in snowpack, maximum and minimum temperature, and the seasonal timing of runoff over mountainous regions of the western United States.[34] Human activity is likely to have made a substantial contribution to ocean surface temperature changes in hurricane formation regions.[66-68] Researchers are also looking beyond the physical climate system, and are beginning to tie changes in the distribution and seasonal behavior of plant and animal species to human-caused changes in temperature and precipitation.[69,70]

For over a decade, one aspect of the climate change story seemed to show a significant difference between models and observations.[14]

In the tropics, all models predicted that with a rise in greenhouse gases, the troposphere would be expected to warm more rapidly than the surface. Observations from weather balloons, satellites, and surface thermometers seemed to show the opposite behavior (more rapid warming of the surface than the troposphere). This issue was a stumbling block in our understanding of the causes of climate change. It is now largely resolved.[71] Research showed that there were large uncertainties in the satellite and weather balloon data. When uncertainties in models and observations are properly accounted for, newer observational data sets (with better treatment of known problems) are in agreement with climate model results.[31,72-75]



Climate simulations of the vertical profile of temperature change due to various factors, and the effect due to all factors taken together. The panels above represent a cross-section of the atmosphere from the north pole to the south pole, and from the surface up into the stratosphere. The black lines show the location of the tropopause, the boundary between the lower atmosphere (troposphere) and the stratosphere.

This does not mean, however, that all remaining differences between models and observations have been resolved. The observed changes in some climate variables, such as Arctic sea ice,[61,76] some aspects of precipitation,[54,77] and patterns of surface pressure,[56] appear to be proceeding much more rapidly than models have projected. The reasons for these differences are not well understood. Nevertheless, the bottom-line conclusion from climate fingerprinting is that most of the observed changes studied to date are consistent with each other, and are also consistent with our scientific understanding of how the climate system would be expected to respond to the increase in heat-trapping gases resulting from human activities.[14,49]

Scientists are sometimes asked whether extreme weather events can be linked to human activities.[24] Scientific research has concluded that human influences on climate are indeed changing the likelihood of certain types of extreme events. For example, an analysis of the European summer heat wave of 2003 found that the risk of such a heat wave is now roughly four times greater than it would have been in the absence of human-induced climate change.[68,78]

Like fingerprint work, such analyses of human-caused changes in the risks of extreme events rely on information from climate models, and on our understanding of the physics of the climate system. All of the models used in this work have imperfections in their representation of the complexities of the "real world" climate system.[79,80] These are due to both limits in our understanding of the climate system, and in our ability to represent its complex behavior with available computer resources. Despite this, models are extremely useful, for a number of reasons.

First, despite remaining imperfections, the current generation of climate models accurately portrays many important aspects of today's weather patterns and climate.[79,80] Models are constantly being improved, and are routinely tested against many observations of Earth's climate system. Second, the fingerprint work shows that models capture not only our present-day climate, but also key features of the observed climate changes over the past century.[47] Third, many of the large-scale observed climate changes (such as the warming of the surface and troposphere, and the increase in the amount of moisture in the atmosphere) are driven by very basic physics, which is well-represented in models.[35] Fourth, climate models can be used to predict changes in climate that can be verified in the real world. Examples include the short-term global cooling subsequent to the eruption of Mount Pinatubo and the stratospheric cooling with increasing carbon dioxide. Finally, models are the only tools that exist for trying to understand the climate changes likely to be experienced over the course of this century. No period in Earth's geological history provides an exact analogue for the climate conditions that will unfold in the coming decades.[20]

Global temperatures are projected to continue to rise over this century; by how much and for how long depends on a number of factors, including the amount of heat-trapping gas emissions and how sensitive the climate is to those emissions.

Some continued warming of the planet is projected over the next few decades due to past emissions. Choices made now will influence the amount of future warming. Lower levels of heat-trapping emissions will yield less future warming, while higher levels will result in more warming, and more severe impacts on society and the natural world.

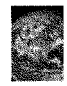
Emissions scenarios

The IPCC developed a set of scenarios in a Special Report on Emissions Scenarios (SRES).[81] These have been extensively used to explore the potential for future climate change. None of these scenarios, not even the one called "lower", includes implementation of policies to limit climate change or to stabilize atmospheric concentrations of heat-trapping gases. Rather, differences among these scenarios are due to different assumptions about changes in population, rate of adoption of new technologies, economic growth, and other factors.

The IPCC emission scenarios also do not encompass the full range of possible futures: emissions can change less than those scenarios imply, or they can change more. Recent carbon dioxide emissions are, in fact, above the highest emissions scenario developed by the IPCC[82] (see figure below). Whether this will continue is uncertain.

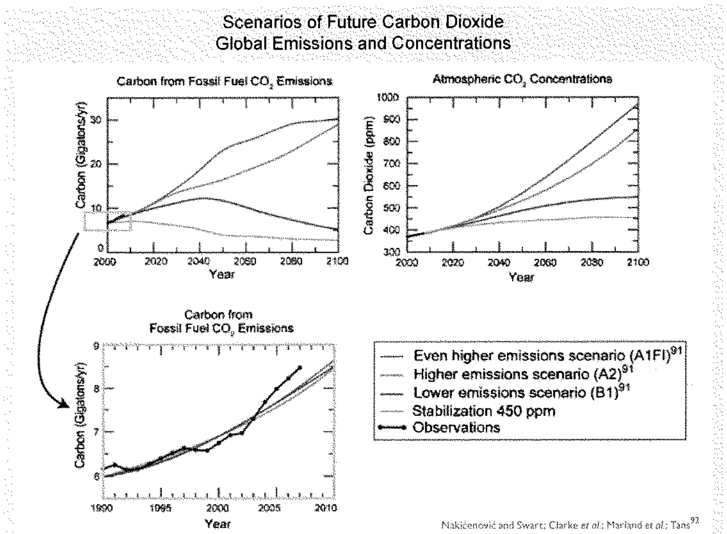
There are also lower possible emissions paths than those put forth by the IPCC. The Framework Convention on Climate Change, to which the United States and 191 other countries are signatories, calls for stabilizing concentrations of greenhouse gases in the atmosphere at a level that would avoid dangerous human interference with the climate system. What exactly constitutes such interference is subject to interpretation.

A variety of research studies suggest that a further 2°F increase (relative to the 1980-1999 period) would lead to severe, widespread, and irreversible impacts.[83-85] To have a good chance (but not a guarantee) of avoiding temperatures above those levels, it has been estimated that atmospheric concentration of carbon dioxide would need to stabilize in the long term at around today's levels.[86-89]



Reducing emissions of carbon dioxide would reduce warming over this century and beyond. Implementing sizable and sustained reductions in carbon dioxide emissions as soon as possible would significantly reduce the pace and the overall amount of climate change, and would be more effective than reductions of the same size initiated later. Reducing emissions of some shorter-lived greenhouse gases, such as methane, and some types of particles, such as soot, would begin to reduce the warming influence within weeks to decades.[13]

The graphs below show emissions scenarios and resulting carbon dioxide concentrations for three IPCC scenarios[90,91] and one stabilization scenario.[25]



Nakićenović and Swart; Clarke *et al.*; Marland *et al.*; Tans[92]

The graphs show recent and projected global emissions of carbon dioxide in gigatons of carbon, on the left, and atmospheric concentrations on the right under five emissions scenarios. The top three in the key are IPCC scenarios that assume no explicit climate policies (these are used in model projections that appear throughout this report). The bottom line is a "stabilization scenario," designed to stabilize atmospheric carbon dioxide concentration at 450 parts per million. The inset expanded below these charts shows emissions for 1990-2010 under the three IPCC scenarios along with actual emissions to 2007 (in black).

The stabilization scenario is aimed at stabilizing the atmospheric carbon dioxide concentration at roughly 450 parts per million (ppm); this is 70 ppm above the 2008 concentration of 385 ppm. Resulting temperature changes depend on atmospheric concentrations of greenhouse gases and particles and the climate's sensitivity to those concentrations.[87] Of those shown on the previous page, only the 450 ppm stabilization target has the potential to keep the global temperature rise at or below about 3.5°F from pre-industrial levels and 2°F above the current average temperature, a level beyond which many concerns have been raised about dangerous human interference with the climate system.[88,89] Scenarios that stabilize carbon dioxide below 450 ppm (not shown in the figure) offer an increased chance of avoiding dangerous climate change.[88,89]

Carbon dioxide is not the only greenhouse gas of concern. Concentrations of other heat-trapping gases like methane and nitrous oxide and particles like soot will also have to be stabilized at low enough levels to prevent global temperatures from rising higher than the level mentioned above. When these other gases are added, including the offsetting cooling effects of sulfate aerosol particles, analyses suggest that stabilizing concentrations around 400 parts per million of "equivalent carbon dioxide" would yield about an 80 percent chance of avoiding exceeding the 2°F above present temperature threshold. This would be true even if concentrations temporarily peaked as high as 475 parts per million and then stabilized at 400 parts per million roughly a century later.[72,88,89,93-95] Reductions in sulfate aerosol particles would necessitate lower equivalent carbon dioxide targets.

Rising global temperature

All climate models project that human-caused emissions of heat-trapping gases will cause further warming in the future. Based on scenarios that do not assume explicit climate policies to reduce greenhouse gas emissions, global average temperature is projected to rise by 2 to 11.5°F by the end of this century[90] (relative to the 1980-1999 time period). Whether the actual warming in 2100 will be closer to the low or the high end of this range depends primarily on two factors: first, the future level of emissions of heat-trapping gases, and second, how sensitive climate is to past and future emissions. The range of possible outcomes has been explored using a range of different emissions scenarios, and a variety of climate models that encompass the known range of climate sensitivity.

Changing precipitation patterns

Projections of changes in precipitation largely follow recently observed patterns of change, with overall increases in the global average but substantial shifts in where and how precipitation falls.[90] Generally, higher latitudes are projected to receive more precipitation, while the dry belt that lies just outside the tropics expands further poleward,[96,97] and also receives less rain. Increases in tropical precipitation are projected during rainy seasons (such as monsoons), and especially over the tropical Pacific. Certain regions, including the U.S. West (especially the Southwest) and the Mediterranean, are expected to become drier. The widespread trend toward more heavy downpours is expected to continue, with precipitation becoming less frequent but more intense.[90] More precipitation is expected to fall as rain rather than snow.

Currently rare extreme events are becoming more common

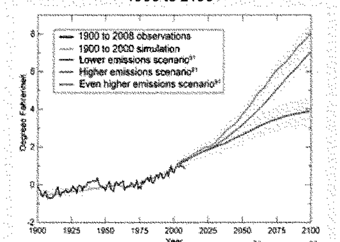
In a warmer future climate, models project there will be an increased risk of more intense, more frequent, and longer-lasting heat waves.[90] The European heat wave of 2003 is an example of the type of extreme heat event that is likely to become much more common.[90] If greenhouse gas emissions continue to increase, by the 2040s more than half of European summers will be hotter than the summer of 2003, and by the end of this century, a summer as hot as that of 2003 will be considered unusually cool.[78]

Increased extremes of summer dryness and winter wetness are projected for much of the globe, meaning a generally greater risk of droughts and floods. This has already been observed,[55] and is projected to continue. In a warmer world, precipitation tends to be concentrated into heavier events, with longer dry periods in between.[90]

Models project a general tendency for more intense but fewer storms overall outside the tropics, with more extreme wind events and higher ocean waves in a number of regions in association with those storms. Models also project a shift of storm tracks toward the poles in both hemispheres.[90]

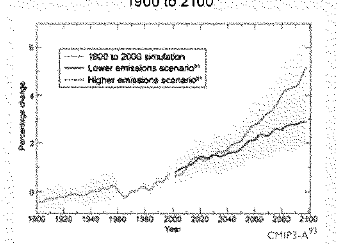
Changes in hurricanes are difficult to project because there are countervailing forces. Higher ocean temperatures lead to stronger storms with higher wind speeds and more rainfall.[98] But changes in wind speed and direction with height are also projected to increase in some regions, and this tends to work against storm formation and growth.[99-101] It currently appears that stronger, more rain-producing tropical storms and hurricanes are generally

Global Average Temperature
1900 to 2100



Observed and projected changes in the global average temperature under three IPCC no-policy emissions scenarios. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. A wider range of model types shows outcomes from 2 to 11.5°F.[90] Changes are relative to the 1960-1979 average.

Global Increase in Heavy Precipitation
1900 to 2100



Simulated and projected changes in the amount of precipitation falling in the heaviest 5 percent of daily events. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. Changes are relative to the 1960-1979 average.

more likely, though more research is required on these issues.[68] More discussion of Atlantic hurricanes, which most affect the United States, appears on page 34 in the *National Climate Change* section.

Sea level will continue to rise

Projecting future sea-level rise presents special challenges. Scientists have a well-developed understanding of the contributions of thermal expansion and melting glaciers to sea-level rise, so the models used to project sea-level rise include these processes. However, the contributions to past and future sea-level rise from ice sheets are less well understood. Recent observations of the polar ice sheets show that a number of complex processes control the movement of ice to the sea, and thus affect the contributions of ice sheets to sea-level rise.[29] Some of these processes are already producing substantial loss of ice mass. Because these processes are not well understood it is difficult to predict their future contributions to sea-level rise.[102]

Because of this uncertainty, the 2007 assessment by the IPCC could not quantify the contributions to sea-level rise due to changes in ice sheet dynamics, and thus projected a rise of the world's oceans from 8 inches to 2 feet by the end of this century.[90]

More recent research has attempted to quantify the potential contribution to sea-level rise from the accelerated flow of ice sheets to the sea[27,42] or to estimate future sea level based on its observed relationship to temperature.[103] The resulting estimates exceed those of the IPCC, and the average estimates under higher emissions scenarios are for sea-level rise between 3 and 4 feet by the end of this century. An important question that is often asked is, what is the upper bound of sea-level rise expected over this century? Few analyses have focused on this question. There is some evidence to suggest that it would be virtually impossible to have a rise of sea level higher than about 6.5 feet by the end of this century.[42]

The changes in sea level experienced at any particular location along the coast depend not only on the increase in the global average sea level, but also on changes in regional currents and winds, proximity to the mass of melting ice sheets, and on the vertical movements of the land due to geological

forces.[104] The consequences of sea-level rise at any particular location depend on the amount of sea-level rise relative to the adjoining land. Although some parts of the U.S. coast are undergoing uplift (rising), most shorelines are subsiding (sinking) to various degrees – from a few inches to over 2 feet per century.

Abrupt climate change

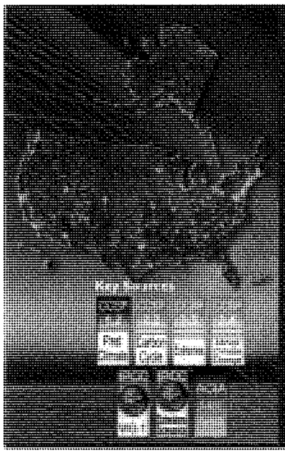
There is also the possibility of even larger changes in climate than current scenarios and models project. Not all changes in the climate are gradual. The long record of climate found in ice cores, tree rings, and other natural records show that Earth's climate patterns have undergone rapid shifts from one stable state to another within as short a period as a decade. The occurrence of abrupt changes in climate becomes increasingly likely as the human disturbance of the climate system grows.[90] Such changes can occur so rapidly that they would challenge the ability of human and natural systems to adapt.[105] Examples of such changes are abrupt shifts in drought frequency and duration. Ancient climate records suggest that in the United States, the Southwest may be at greatest risk for this kind of change, but that other regions including the Midwest and Great Plains have also had these kinds of abrupt shifts in the past and could experience them again in the future.

Rapid ice sheet collapse with related sea-level rise is another type of abrupt change that is not well understood or modeled and that poses a risk for the future. Recent observations show that melting on the surface of an ice sheet produces water that flows down through large cracks that create conduits through the ice to the base of the ice sheet where it lubricates ice previously frozen to the rock below.[29] Further, the interaction with warm ocean water, where ice meets the sea, can lead to sudden losses in ice mass and accompanying rapid global sea-level rise. Observations indicate that ice loss has increased dramatically over the last decade, though scientists are not yet confident that they can project how the ice sheets will respond in the future.

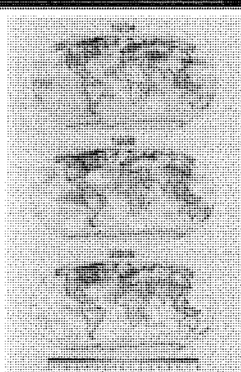
There are also concerns regarding the potential for abrupt release of methane from thawing of frozen soils, from the sea floor, and from wetlands in the tropics and the Arctic. While analyses suggest that an abrupt release of methane is very unlikely to occur within 100 years, it is very likely that warming will accelerate the pace of chronic methane emissions from these sources, potentially increasing the rate of global temperature rise.[106]

A third major area of concern regarding possible abrupt change involves the operation of the ocean currents that transport vast quantities of heat around the globe. One branch of the ocean circulation is in the North Atlantic. In this region, warm water flows northward from the tropics to the North Atlantic in the upper layer of the ocean, while cold water flows back from the North Atlantic to the tropics in the ocean's deep layers, creating a "conveyor belt" for heat. Changes in this circulation have profound impacts on the global climate system, from changes in African and Indian monsoon rainfall, to atmospheric circulation relevant to hurricanes, to changes in climate over North America and Western Europe.

Recent findings indicate that it is very likely that the strength of this North Atlantic circulation will decrease over the course of this century in response to increasing greenhouse gases. This is expected because warming increases the melting of glaciers and ice sheets and the resulting runoff of freshwater to the sea. This additional water is virtually salt-free, which makes it less dense than sea water. Increased precipitation also contributes fresh, less-dense water to the ocean. As a result, less surface water is dense enough to sink, thereby reducing the conveyor belt's transport of heat. The best estimate is that the strength of this circulation will decrease 25 to 30 percent in this century, leading to a reduction in heat transfer to the North Atlantic. It is considered very unlikely that this circulation would collapse entirely during the next 100 years or so, though it cannot be ruled out. While very unlikely, the potential consequences of such an abrupt event would be severe. Impacts would likely include sea-level rise around the North Atlantic of up to 2.5 feet (in addition to the rise expected from thermal expansion and melting glaciers and ice sheets), changes in atmospheric circulation conditions that influence hurricane activity, a southward shift of tropical rainfall belts with resulting agricultural impacts, and disruptions to marine ecosystems.[76]

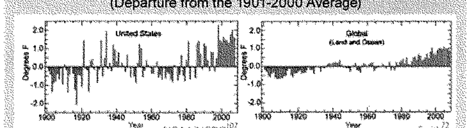


National Climate Change

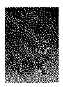


Like the rest of the world, the United States has been warming significantly over the past 50 years in response to the build up of heat-trapping gases in the atmosphere. When looking at national climate, however, it is important to recognize that climate responds to local, regional, and global factors. Therefore, national climate varies more than the average global climate. While various parts of the world have had particularly hot or cold periods earlier in the historical record, these periods have not been global in scale, whereas the warming of recent decades has been global in scale – hence the term *global* warming. It is also important to recognize that at both the global and national scales, year-to-year fluctuations in natural weather and climate patterns can produce a period that does not follow the long-term trend. Thus, each year will not necessarily be warmer than every year before it, though the warming trend continues.

Annual Average Temperature
(Departure from the 1901-2000 Average)



From 1901 to 2008, each year's temperature departure from the long-term average is one bar, with blue bars representing years cooler than the long-term average and red bars representing years warmer than that average. National temperatures vary much more than global temperatures, in part because of the moderating influence of the oceans on global temperatures.



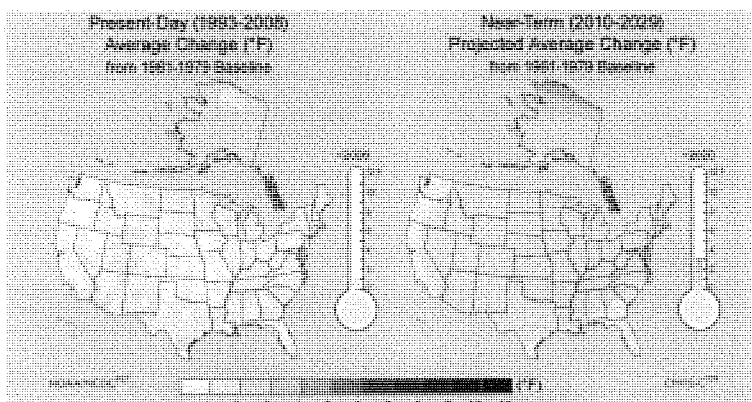
U.S. average temperature has risen more than 2°F over the past 50 years and is projected to rise more in the future; how much more depends primarily on the amount of heat-trapping gases emitted globally and how sensitive the climate is to those emissions.

The series of maps and thermometers on these two pages shows the magnitude of the observed and projected changes in annual average temperature. The map for the period around 2000 shows that most areas of the United States have warmed 1 to 2°F compared to the 1960s and 1970s. Although not reflected in these maps of annual average temperature, this warming has generally resulted in longer warm seasons and shorter, less intense cold seasons.

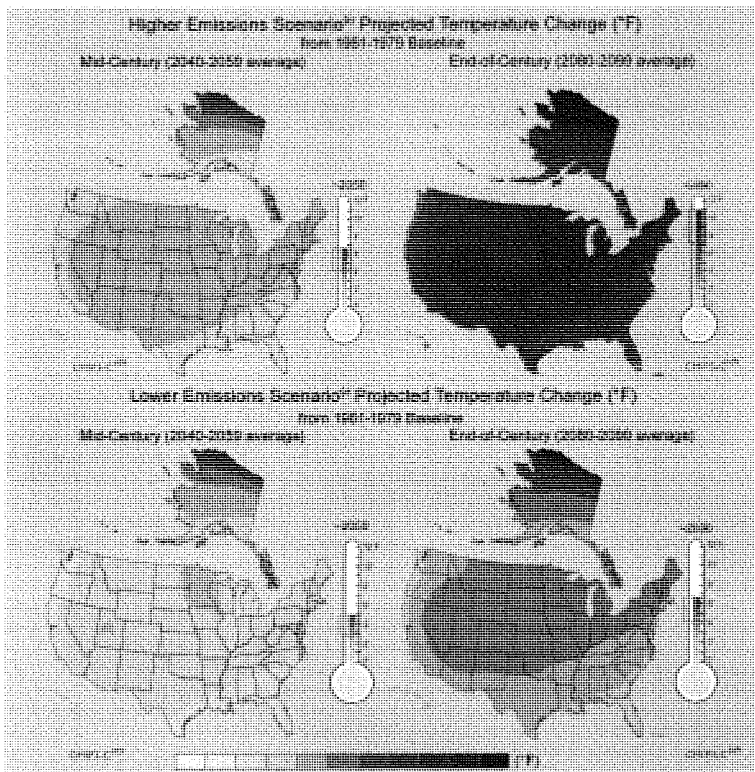
The remaining maps show projected warming over the course of this century under a lower emissions scenario and a higher emissions scenario[91] (see *Global Climate Change* section, page 23). Temperatures will continue to rise throughout the century under both emissions scenarios,[91] although higher emissions result in more warming by the middle of the century and significantly more by the end of the century.

Temperature increases in the next couple of decades will be primarily determined by past emissions of heat-trapping gases. As a result, there is little difference in projected temperature between the higher and lower emissions scenarios[91] in the near-term (around 2020), so only a single map is shown for this timeframe. Increases after the next couple of decades will be primarily determined by future emissions.[90] This is clearly evident in greater projected warming in the higher emissions scenario[91] by the middle (around 2050) and end of this century (around 2090).

On a seasonal basis, most of the United States is projected to experience greater warming in summer than in winter, while Alaska experiences far more warming in winter than summer.[108]



The average warming for the country as a whole is shown on the thermometers adjacent to each map. By the end of the century, the average U.S. temperature is projected to increase by approximately 7 to 11°F under the higher emissions scenario[91] and by approximately 4 to 6.5°F under the lower emissions scenario.[91] These ranges are due to differences among climate model results for the same emissions scenarios. Emissions scenarios even lower than the lower scenario shown here, such as the 450 ppm stabilization scenario described on pages 23-24, would yield lower temperature increases than those shown below.[25]



The maps on this page and the previous page are based on projections of future temperature by 16 of the Coupled Model Intercomparison Project Three (CMIP3) climate models using two emissions scenarios from the Intergovernmental Panel on Climate Change (IPCC), Special Report on Emission Scenarios (SRES). The "lower" scenario here is B1, while the "higher" is A2. The brackets on the thermometers represent the likely range of model projections, though lower or higher outcomes are possible. Additional information on these scenarios is on pages 22 and 23 in the previous section, Global Climate Change. These maps, and others in this report, show projections at national, regional, and sub-regional scales, using well-established techniques.

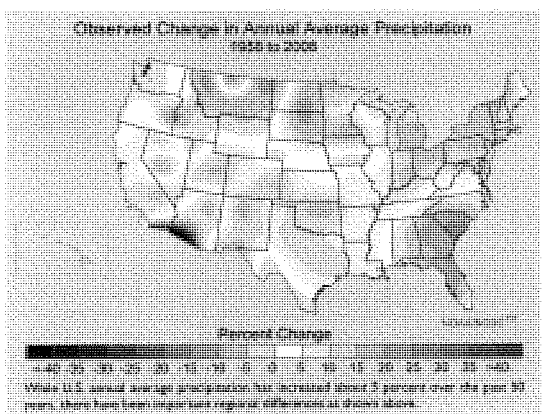
Precipitation has increased an average of about 5 percent over the past 50 years. Projections of future precipitation generally indicate that northern areas will become wetter, and southern areas, particularly in the West, will become drier.

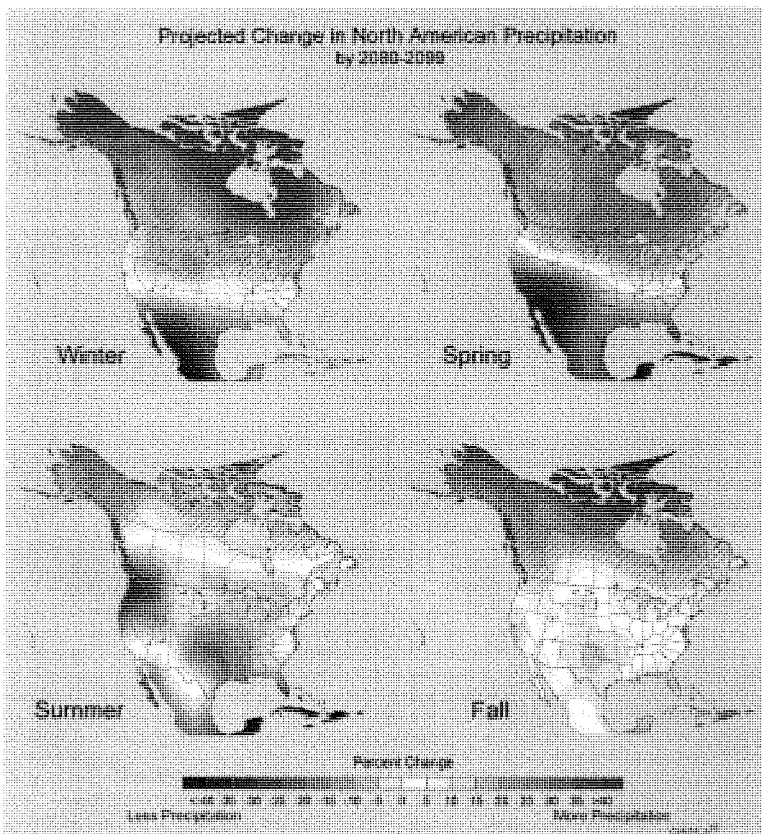
While precipitation over the United States as a whole has increased, there have been important regional and seasonal differences. Increasing trends throughout much of the year have been predominant in the Northeast and large parts of the Plains and Midwest. Decreases occurred in much of the Southeast in all but the fall season and in the Northwest in all seasons except spring. Precipitation also generally decreased during the summer and fall in the Southwest, while winter and spring, which are the wettest seasons in states such as California and Nevada, have had increases in precipitation.[111]

Future changes in total precipitation due to human-induced warming are more difficult to project than changes in temperature. In some seasons, some areas will experience an increase in precipitation, other areas will experience a decrease, and others will see little discernible change. The difficulty arises in predicting the extent of those areas and the amount of change. Model projections of future precipitation generally indicate that northern areas will become wetter, and southern areas, particularly in the West, will become drier.[97,108]

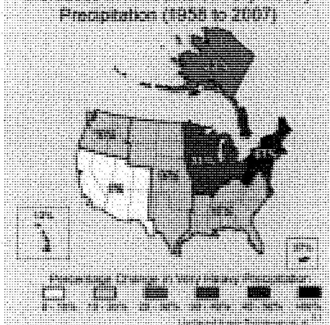
Confidence in projected changes is higher for winter and spring than for summer and fall. In winter and spring, northern areas are expected to receive significantly more precipitation than they do now, because the interaction of warm and moist air coming from the south with colder air from the north is projected to occur farther north than it did on average in the last century. The more northward incursions of warmer and moister air masses are expected to be particularly noticeable in northern regions that will change from very cold and dry atmospheric conditions to warmer but moister conditions.[68] Alaska, the Great Plains, the upper Midwest, and the Northeast are beginning to experience such changes for at least part of the year, with the likelihood of these changes increasing over time.

In some northern areas, warmer conditions will result in more precipitation falling as rain and less as snow. In addition, potential water resource benefits from increasing precipitation could be countered by the competing influences of increasing evaporation and runoff. In southern areas, significant reductions in precipitation are projected in winter and spring as the subtropical dry belt expands.[108] This is particularly pronounced in the Southwest, where it would have serious ramifications for water resources.




Projected Change in North American Precipitation
by 2080-2099
Winter
Spring
Summer
Fall
Percent Change
Less Precipitation
More Precipitation

Increases in Amounts of Very Heavy Precipitation (1958 to 2007)



The map shows percent increases in the amount falling in very heavy precipitation events (defined as the heaviest 1 percent of all daily events) from 1958 to 2007 for each region. There are clear trends toward more very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

The amount of rain falling in the heaviest downpours has increased approximately 20 percent on average in the past century, and this trend is very likely to continue, with the largest increases in the wettest places.

One of the clearest precipitation trends in the United States is the increasing frequency and intensity of heavy downpours. This increase was responsible for most of the observed increase in overall precipitation during the last 50 years. In fact, there has been little change or a decrease in the frequency of light and moderate precipitation during the past 30 years, while heavy precipitation has increased. In addition, while total average precipitation over the nation as a whole increased by about 7 percent over the past century, the amount of precipitation falling in the heaviest 1 percent of rain events increased nearly 20 percent.[112]

During the past 50 years, the greatest increases in heavy precipitation occurred in the Northeast and the Midwest. There have also been increases in heavy downpours in the other regions of the continental United States, as well as Alaska, Hawaii, and Puerto Rico.[112]

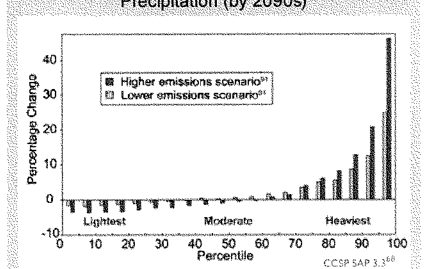
Climate models project continued increases in the heaviest downpours during this century, while the lightest precipitation is projected to decrease. Heavy downpours that are now 1-in-20-year occurrences are projected to occur about every 4 to 15 years by the end of this century, depending on location, and the intensity of heavy downpours is also expected to increase. The 1-in-20-year heavy downpour is expected to be between 10 and 25 percent heavier by the end of the century than it is now.[112]

Changes in these kinds of extreme weather and climate events are among the most serious challenges to our nation in coping with a changing climate.

Many types of extreme weather events, such as heat waves and regional droughts, have become more frequent and intense during the past 40 to 50 years.

Many extremes and their associated impacts are now changing. For example, in recent decades most of North America has been experiencing more unusually hot days and nights, fewer unusually cold days and nights, and fewer frost days. Droughts are becoming more severe in some regions. The power and frequency of Atlantic hurricanes have increased substantially in recent decades. The number of North American mainland landfalling hurricanes does

Projected Changes in Light, Moderate, and Heavy Precipitation (by 2090s)

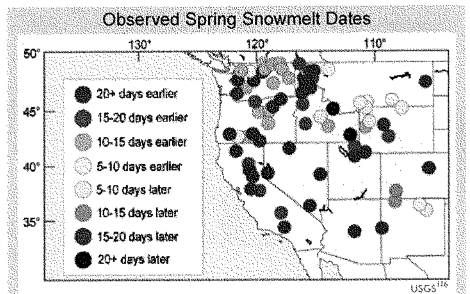


The figure shows projected changes from the 1990s average to the 2090s average in the amount of precipitation falling in light, moderate, and heavy events in North America. Projected changes are displayed in 5 percent increments from the lightest drizzles to the heaviest downpours. As shown here, the lightest precipitation is projected to decrease, while the heaviest will increase, continuing the observed trend. The higher emission scenario[91] yields larger changes. Projections are based on the models used in the IPCC 2007 Fourth Assessment Report.

not appear to have increased over the past century. Outside the tropics, cold-season storm tracks are shifting northward and the strongest storms are becoming even stronger. These trends in storms outside the tropics are projected to continue throughout this century.[68,112,114]

Drought

Like precipitation, trends in drought have strong regional variations. In much of the Southeast and large parts of the West, the frequency of drought has increased coincident with rising temperatures over the past 50 years. In other regions, such as the Midwest and Great Plains, there has been a reduction in drought frequency.



Date of onset of spring runoff pulse. Reddish-brown circles indicate significant trends toward onsets more than 20 days earlier. Lighter circles indicate less advance of the onset. Blue circles indicate later onset. The changes depend on a number of factors in addition to temperature, including altitude and timing of snowfall.

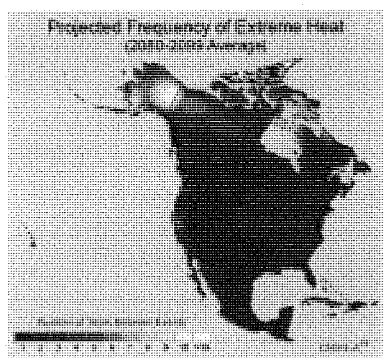
Although there has been an overall increase in precipitation and no clear trend in drought for the nation as a whole, increasing temperatures have made droughts more severe and widespread than they would have otherwise been. Without the observed increase in precipitation, higher temperatures would have led to an increase in the area of the contiguous United States in severe to extreme drought, with some estimates of a 30 percent increase.[112] In the future, droughts are likely to become more frequent and severe in some regions.[68] The Southwest, in particular, is expected to experience increasing drought as changes in atmospheric circulation patterns cause the dry zone just outside the tropics to expand farther northward into the United States.[97]

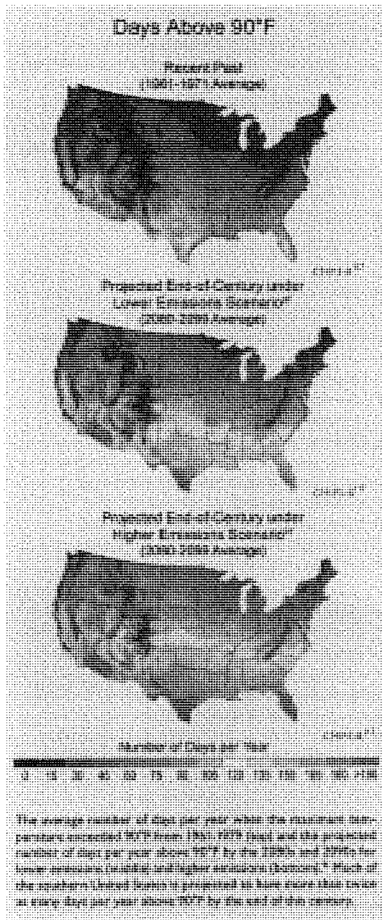
Rising temperatures have also led to earlier melting of the snowpack in the western United States.[40] Because snowpack runoff is critical to the water resources in the western United States, changes in the timing and amount of runoff can exacerbate problems with already limited water supplies in the region.

Heat waves

A heat wave is a period of several days to weeks of abnormally hot weather, often with high humidity. During the 1930s, there was a high frequency of heat waves due to high daytime temperatures resulting in large part from an extended multi-year period of intense drought. By contrast, in the past 3 to 4 decades, there has been an increasing trend in high-humidity heat waves, which are characterized by the persistence of extremely high nighttime temperatures.[112]

As average temperatures continue to rise throughout this century, the frequency of cold extremes will decrease and the frequency and intensity of high temperature extremes will increase.[115] The number of days with high temperatures above





90°F is projected to increase throughout the country as illustrated in the maps on the left. Parts of the South that currently have about 60 days per year with temperatures over 90°F are projected to experience 150 or more days a year above 90°F by the end of this century, under a higher emissions scenario.[91] There is higher confidence in the regional patterns than in results for any specific location (see *An Agenda for Climate Impacts Science* section).

With rising high temperatures, extreme heat waves that are currently considered rare will occur more frequently in the future. Recent studies using an ensemble of models show that events that now occur once every 20 years are projected to occur about every other year in much of the country by the end of this century. In addition to occurring more frequently, at the end of this century these very hot days are projected to be about 10°F hotter than they are today.[68]

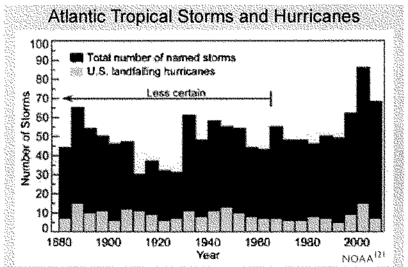
The destructive energy of Atlantic hurricanes has increased in recent decades. The intensity of these storms is likely to increase in this century.

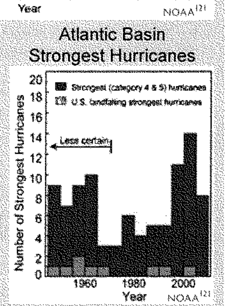
Of all the world's tropical storm and hurricane basins, the North Atlantic has been the most thoroughly monitored and studied. The advent of routine aircraft monitoring in the 1940s and the use of satellite observations since the 1960s have greatly aided monitoring of tropical storms and hurricanes. In addition, observations of tropical storm and hurricane strength made from island and mainland weather stations and from ships at sea began in the 1800s and continue today. Because of new and evolving observing techniques and technologies, scientists pay careful attention to ensuring consistency in tropical storm and hurricane records from the earliest manual observations to today's automated measurements. This is accomplished through collection, analysis, and cross-referencing of data from numerous sources and, where necessary, the application of adjustment techniques to account for differences in observing and reporting methodologies through time. Nevertheless, data uncertainty is larger in the early part of the record. Confidence in the tropical storm and hurricane record increases after 1900 and is greatest during the satellite era, from 1965 to the present.[112]

The total number of hurricanes and strongest hurricanes (Category 4 and 5) observed from 1881 through 2008 shows multi-decade periods of above average activity in the 1800s, the mid-1900s, and since 1995. The power and frequency of Atlantic hurricanes have increased substantially in recent decades.[112] There has been little change in the total number of landfalling hurricanes, in part because a variety of factors affect whether a hurricane will make landfall. These include large-scale steering winds, atmospheric stability, wind shear, and ocean heat content. This highlights the importance of understanding the broader changes occurring throughout the Atlantic Basin beyond the storms making landfall along the U.S. coast.[112]

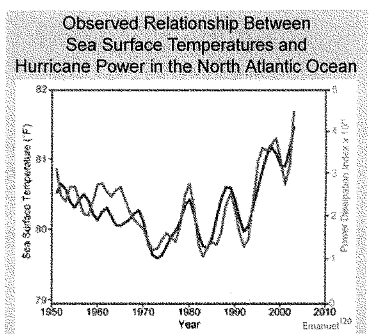
Tropical storms and hurricanes develop and gain strength over warm ocean waters. As oceans warm, they provide a source of energy for hurricane growth. During the past 30 years, annual sea surface temperatures in the main Atlantic hurricane development region increased nearly 2°F. This warming coincided with an increase in the destructive energy (as defined by the Power Dissipation Index, a combination of intensity, duration, and frequency) of Atlantic tropical storms and hurricanes. The strongest hurricanes (Category 4 and 5) have, in particular, increased in intensity.[112] The graph below shows the strong correlation between hurricane power and sea surface temperature in the Atlantic and the overall increase in both during the past 30 years. Climate models project that hurricane intensity will continue to increase, though at a lesser rate than that observed in recent decades.[100]

New evidence has emerged recently for other temperature related linkages that can help

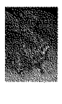




Top: Total numbers of North Atlantic named storms (tropical storms and hurricanes) (black) and total U.S. landfalling hurricanes (yellow) in 5-year periods based on annual data from 1881 to 2008. The bar for the last 5-year period is based on the assumption that the level of activity from 2006 to 2008 persists through 2010. In the era before satellites, indicated by the arrow above, the total number of named storms is less certain and has been adjusted upward to account for missing storms. Adjustments are based on relationships established during the satellite era between the number of observed storms and the number that would have been missed if satellite data had not been available. **Bottom:** Total number of strongest (Category 4 and 5) North Atlantic basin hurricanes (purple) and strongest U.S. landfalling hurricanes (orange) in 5-year periods based on annual data from 1946 to 2008. The bar for the last 5-year period is based on the assumption that the level of activity from 2006 to 2008 persists through 2010. From 1946 to the mid-1960s, as indicated by the arrow above, hurricane intensity was measured primarily by aircraft reconnaissance. Data prior to aircraft reconnaissance are not shown due to the greater uncertainty in estimates of a hurricane's maximum intensity. Satellites have increased the reliability of hurricane intensity estimates since the mid-1960s.



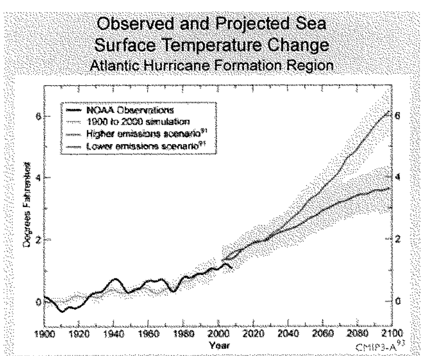
Observed sea surface temperature (blue) and the Power Dissipation Index (green), which combines frequency, intensity and duration for North Atlantic hurricanes.[120] Hurricane rainfall and wind speeds are likely to increase in response to human-caused warming. Analyses of model simulations suggest that for each 1.8°F increase in tropical sea surface temperatures, rainfall rates will increase by 6 to 18 percent.[69]



explain the increase in Atlantic hurricane activity. This includes the contrast in sea surface temperature between the main hurricane development region and the broader tropical ocean.[99,118,119] Other causes beyond the rise in ocean temperature, such as atmospheric stability and circulation, can also influence hurricane power. For these and other reasons, a confident assessment requires further study.[68]

Evidence of increasing hurricane strength in the Atlantic and other oceans with linkages to rising sea surface temperatures is also supported by satellite records dating back to 1981. An increase in the maximum wind speeds of the strongest hurricanes has been documented and linked to increasing sea surface temperatures.[122]

Projections are that sea surface temperatures in the main Atlantic hurricane development region will increase at even faster rates during the second half of this century under higher emissions scenarios. This highlights the need to better understand the relationship between increasing temperatures and hurricane intensity. As ocean temperatures continue to increase in the future, it is likely that hurricane rainfall and wind speeds will increase in response to human-caused warming.[68] Analyses



Observed (black) and projected temperatures (blue = lower scenario; red = higher scenario) in the Atlantic hurricane formation region. Increased intensity of hurricanes is linked to rising sea surface temperatures in the region of the ocean where hurricanes form. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models.

of model simulations suggest that for each 1.8°F increase in tropical sea surface temperatures, core rainfall rates will increase by 6 to 18 percent and the surface wind speeds of the strongest hurricanes will increase by about 1 to 8 percent.[114] Even without further coastal development, storm surge levels and hurricane damages are likely to increase because of increasing hurricane intensity coupled with sea-level rise, the latter being a virtually certain outcome of the warming global climate.[68]

In the eastern Pacific, the strongest hurricanes have become stronger since the 1980s, even while the total number of storms has decreased.

Although on average more hurricanes form in the eastern Pacific than the Atlantic each year, cool ocean waters along the U.S. West Coast and atmospheric steering patterns help protect the contiguous U.S. from landfalls. Threats to the Hawaiian Islands are greater, but landfalling storms are rare in comparison to those of the U.S. East and Gulf Coasts. Nevertheless, changes in hurricane intensity and frequency could influence the impact of landfalling Pacific hurricanes in the future.

The total number of tropical storms and hurricanes in the eastern Pacific on seasonal to multi-decade time periods is generally opposite to that observed in the Atlantic. For example, during El Niño events it is common for hurricanes in the Atlantic to be suppressed while the eastern Pacific is more active. This reflects the large-scale atmospheric circulation patterns that extend across both the Atlantic and the Pacific oceans.[123,124]

Within the past three decades the total number of tropical storms and hurricanes and their destructive energy have decreased in the eastern Pacific.[68,124] However, satellite observations have shown that like the Atlantic, the strongest hurricanes (the top 5 percent), have gotten stronger since the early 1980s.[122,125] As ocean temperatures rise, the strongest hurricanes are likely to increase in both the eastern Pacific and the Atlantic.[68]

Sea level has risen along most of the U.S. coast over the past 50 years, and will rise more in the future.

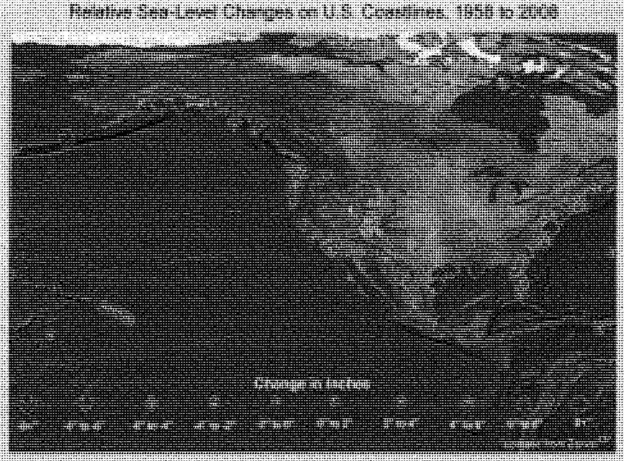
Recent global sea-level rise has been caused by the warming-induced expansion of the oceans, accelerated melting of most of the world's glaciers, and loss of ice on the Greenland and Antarctic ice sheets.[37] There is strong evidence that global sea level is currently rising at an increased rate.[37,126] A warming global climate will cause further sea-level rise over this century and beyond.[90,105]

During the past 50 years, sea level has risen up to 8 inches or more along some coastal areas of the United States, and has fallen in other locations. The amount of relative sea-level rise experienced along different parts of the U.S. coast depends on the changes in elevation of the land that occur as a result of subsidence (sinking) or uplift (rising), as well as increases in global sea level due to warming. In addition, atmospheric and oceanic circulation, which will be affected by climate change, will influence regional sea level. Regional differences in sea-level rise are also expected to be related to where the meltwater originates.[104]

Human-induced sea-level rise is occurring globally. Large parts of the Atlantic Coast and Gulf of Mexico Coast have experienced significantly higher rates of relative sea-level rise than the global average during the last 50 years, with the local differences mainly due to land subsidence.[127] Portions of the Northwest and Alaska coast have, on the other hand, experienced slightly falling sea level as a result of long-term uplift as a consequence of glacier melting and other geological processes.

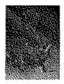
Regional variations in relative sea-level rise are expected in the future. For example, assuming historical geological forces continue, a 2-foot rise in global sea level (which is within the range of recent estimates) by the end of this century would result in a relative sea-level rise of 2.3 feet at New York City, 2.9 feet at Hampton Roads, Virginia, 3.5 feet at Galveston, Texas, and 1 foot at Neah Bay in Washington state.[128]

Relative Sea-Level Changes on U.S. Coastlines, 1958 to 2008



Observed changes in relative sea level from 1958 to 2008 for locations on the U.S. coast. Some areas along the Atlantic and Gulf coasts saw increases greater than 8 inches over the past 50 years.

Cold-season storm tracks are shifting northward and the strongest storms are likely to become stronger and more frequent.



Large-scale storm systems are the dominant weather phenomenon during the cold season in the United States. Although the analysis of these storms is complicated by a relatively short length of most observational records and by the highly variable nature of strong storms, some clear patterns have emerged.[112]

Storm tracks have shifted northward over the last 50 years as evidenced by a decrease in the frequency of storms in mid-latitude areas of the Northern Hemisphere, while high-latitude activity has increased. There is also evidence of an increase in the intensity of storms in both the mid- and high-latitude areas of the Northern Hemisphere, with greater confidence in the increases occurring in high latitudes.[112] The northward shift is projected to continue, and strong cold season storms are likely to become stronger and more frequent, with greater wind speeds and more extreme wave heights.[68]

Snowstorms

The northward shift in storm tracks is reflected in regional changes in the frequency of snowstorms. The South and lower Midwest saw reduced snowstorm frequency during the last century. In contrast, the Northeast and upper Midwest saw increases in snowstorms, although considerable decade-to-decade variations were present in all regions, influenced, for example, by the frequency of El Niño events.[112]

There is also evidence of an increase in lake-effect snowfall along and near the southern and eastern shores of the Great Lakes since 1950.[97] Lake-effect snow is produced by the strong flow of cold air across large areas of relatively warmer ice-free water. As the climate has warmed, ice coverage on the Great Lakes has fallen. The maximum seasonal coverage of Great Lakes ice decreased at a rate of 8.4 percent per decade from 1973 through 2008, amounting to a roughly 30 percent decrease in ice coverage (see *Midwest* region). This has created conditions conducive to greater evaporation of

Areas in New York state east of Lake Ontario received over 10 feet of lake-effect snow during a 10-day period in early February 2007.

moisture and thus heavier snowstorms. Among recent extreme lake-effect snow events was a February 2007 10-day storm total of over 10 feet of snow in western New York state. Climate models suggest that lake-effect snowfalls are likely to increase over the next few decades.[130] In the longer term, lake-effect snows are likely to decrease as temperatures continue to rise, with the precipitation then falling as rain.[129]

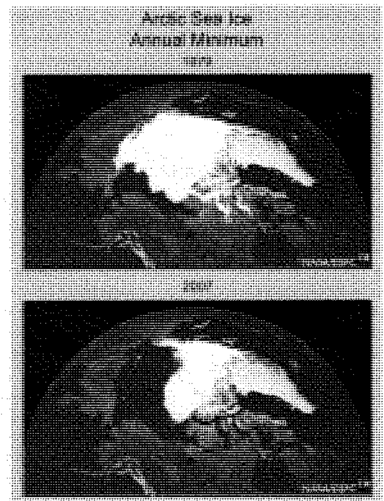
Tornadoes and severe thunderstorms

Reports of severe weather including tornadoes and severe thunderstorms have increased during the past 50 years. However, the increase in the number of reports is widely believed to be due to improvements in monitoring technologies such as Doppler radars combined with changes in population and increasing public awareness. When adjusted to account for these factors, there is no clear trend in the frequency or strength of tornadoes since the 1950s for the United States as a whole.[112]

The distribution by intensity for the strongest 10 percent of hail and wind reports is little changed, providing no evidence of an observed increase in the severity of events.[112] Climate models project future increases in the frequency of environmental conditions favorable to severe thunderstorms.[131] But the inability to adequately model the small-scale conditions involved in thunderstorm development remains a limiting factor in projecting the future character of severe thunderstorms and other small-scale weather phenomena.[68]

Arctic sea ice is declining rapidly and this is very likely to continue.

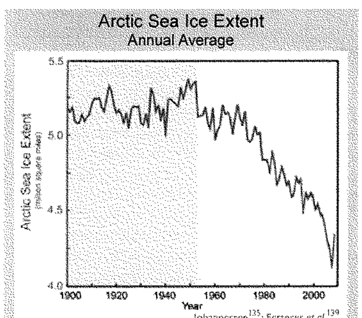
Sea ice is a very important part of the climate system. In addition to direct impacts on coastal areas of Alaska, it more broadly affects surface reflectivity, ocean currents, cloudiness, humidity, and the exchange of heat and moisture at the ocean's surface. Open ocean water is darker in color than sea ice, which causes it to absorb more of the Sun's heat, which increases the warming of the water even more.[40,132]



Arctic sea ice reaches its annual minimum in September. The satellite images above show September Arctic sea ice in 1979, the first year these data were available, and 2007.

The most complete record of sea ice is provided by satellite observations of sea ice extent since the 1970s. Prior to that, aircraft, ship, and coastal observations in the Arctic make it possible to extend the record of Northern Hemisphere sea ice extent back to at least 1900, although there is a lower level of confidence in the data prior to 1953.[40]

Arctic sea ice extent has fallen at a rate of 3 to 4 percent per decade over the last three decades. End-of-summer Arctic sea ice has fallen at an even faster rate of more than 11 percent per decade in that time. The observed decline in Arctic sea ice has been more rapid than projected by climate models.[133] Year-to-year changes in sea ice extent and record low amounts are influenced by natural variations in atmospheric pressure and wind patterns.[134] However, clear linkages between rising greenhouse gas concentrations and declines in Arctic sea ice have been identified in the climate record as far back as the early 1990s.[61] The extreme loss in Arctic sea ice that occurred in 2007 would not have been possible without the long-term reductions that have coincided with a sustained increase in the atmospheric concentration of carbon dioxide and the rapid rise in global temperatures that have occurred since the mid-1970s.[135] Although the 2007 record low was not eclipsed in 2008, the 2008 sea ice extent is well below the long-term average, reflecting a continuation of the long-term decline in Arctic sea ice. In addition, the total volume of Arctic sea ice in 2008 was likely a record low because the ice was unusually thin.[136]

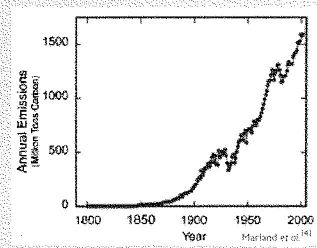


Observations of annual average Arctic sea ice extent for the period 1900 to 2008. The gray shading indicates less confidence in the data before 1953.

It is expected that declines in Arctic sea ice will continue in the coming decades with year-to-year fluctuations influenced by natural atmospheric variability. The overall rate of decline will be influenced mainly by the rate at which carbon dioxide and other greenhouse gas concentrations increase.[137]

U.S. Emission and Absorption of Heat-Trapping Gases

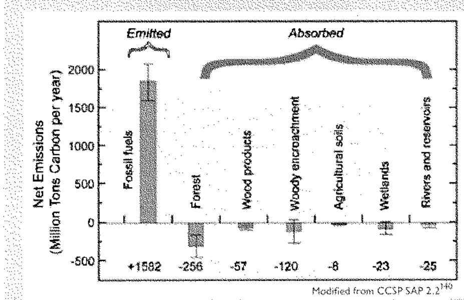
Since the industrial revolution, the United States has been the world's largest emitter of heat-trapping gases. With 4.5 percent of world's population, the United States is responsible for about 28 percent of the human-induced heat-trapping gases in the atmosphere today.[136] Although China has recently surpassed the United States in current total annual emissions, per capita emissions remain much higher in the United States. Carbon dioxide, the most important of the heat-trapping gases produced directly by human activities, is a cumulative problem because it has a long atmospheric lifetime. Roughly one-half of the carbon dioxide released from fossil fuel burning remains in the atmosphere after 100 years, and roughly one-fifth of it remains after 1,000 years.[90]



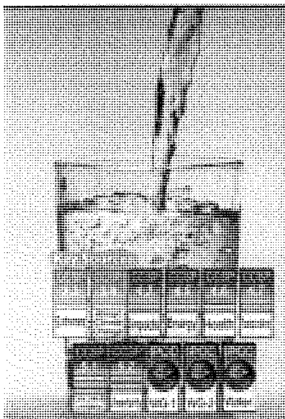
U.S. annual emissions of CO_2 from fossil-fuel use.[141]

U.S. carbon dioxide emissions grew dramatically over the past century. These emissions come almost entirely from burning fossil fuels. These sources of carbon dioxide are one side of the equation and on the other side are "sinks" that take up carbon dioxide. The growth of trees and other plants is an important natural carbon sink. In recent years, it is estimated that about 20 percent of U.S. carbon dioxide emissions have been offset by U.S. forest growth and other sinks (see figure below).[140] It is not known whether U.S. forests and other sinks will continue to take up roughly this amount of carbon dioxide in the future as climate change alters carbon release and uptake. For example, a warming-induced lengthening of the growing season would tend to increase carbon uptake. On the other hand, the increases in forest fires and in the decomposition rate of dead plant matter would decrease uptake, and might convert the carbon sink into a source.[140]

The amount of carbon released and taken up by natural sources varies considerably from year to year depending on climatic and other conditions. For example, fires release carbon dioxide, so years with many large fires result in more carbon release and less uptake as natural sinks (the vegetation) are lost. Similarly, the trees destroyed by intense storms or droughts release carbon dioxide as they decompose, and the loss results in reduced strength of natural sinks until regrowth is well underway. For example, Hurricane Katrina killed or severely damaged over 320 million large trees. As these trees decompose over the next few years, they will release an amount of carbon dioxide equivalent to that taken up by all U.S. forests in a year.[112] The net change in carbon storage in the long run will depend on how much is taken up by the regrowth as well as how much was released by the original disturbance.

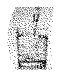


U.S. carbon dioxide emissions and uptake in millions of tons of carbon per year in 2003. The bar marked "Emitted" indicates the amount of carbon as carbon dioxide added to the atmosphere from U.S. emissions. The bars marked "Absorbed" indicate amounts of carbon as carbon dioxide removed from the atmosphere. The thin lines on each bar indicate estimates of uncertainty.



Water Resources

Key Messages:



Changes in the water cycle, which are consistent with the warming observed over the past several decades, include:

- changes in precipitation patterns and intensity
- changes in the incidence of drought
- widespread melting of snow and ice
- increasing atmospheric water vapor
- increasing evaporation
- increasing water temperatures
- reductions in lake and river ice
- changes in soil moisture and runoff

For the future, marked regional differences are projected, with increases in annual precipitation, runoff, and soil moisture in much of the Midwest and Northeast, and declines in much of the West, especially the Southwest.

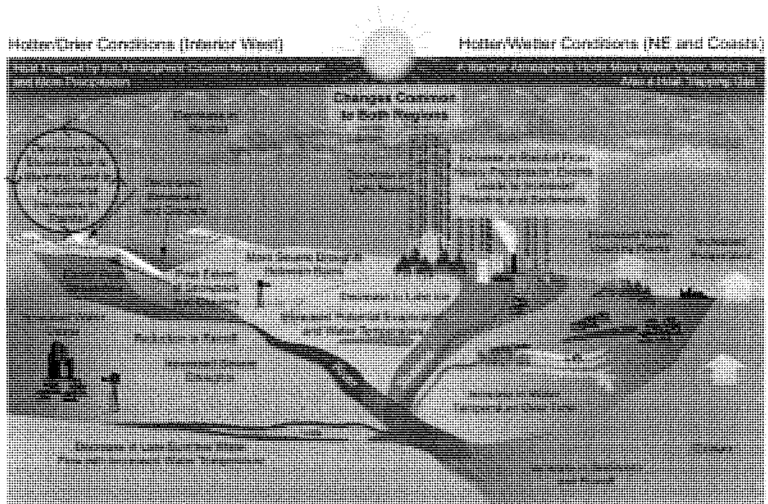
Skagit River and surrounding mountains in the Northwest

The impacts of climate change include too little water in some places, too much water in other places, and degraded water quality. Some locations are expected to be subject to all of these conditions during different times of the year. Water cycle changes are expected to continue and to adversely affect energy production and use, human health, transportation, agriculture, and ecosystems (see table on page 50).[142]

Climate change has already altered, and will continue to alter, the water cycle, affecting where, when, and how much water is available for all uses.

Substantial changes to the water cycle are expected as the planet warms because the movement of water in the atmosphere and oceans is one of the primary mechanisms for the redistribution of heat around the world. Evidence is mounting that human-induced climate change is already altering many of the existing patterns of precipitation in the United States, including when, where, how much, and what kind of precipitation falls.[68,142] A warmer climate increases evaporation of water from land and sea, and allows more moisture to be held in the atmosphere. For every 1°F rise in temperature, the water holding capacity of the atmosphere increases by about 4 percent.[49]

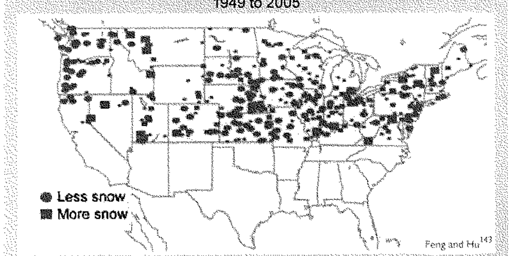
Projected Changes in the Water Cycle



The water cycle exhibits many changes as the Earth warms. Wet and dry areas respond differently. NOAA/NCDC

In addition, changes in atmospheric circulation will tend to move storm tracks northward with the result that dry areas will become drier and wet areas wetter. Hence, the arid Southwest is projected to experience longer and more severe droughts from the combination of increased evaporation and reductions in precipitation.[108]

Changes in Snowfall Contributions to Wintertime Precipitation
1949 to 2005

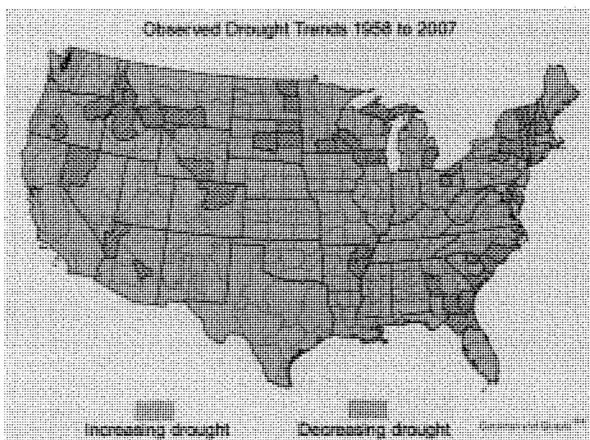


Trends in winter snow-to-total precipitation ratio from 1949 to 2005. Red circles indicate less snow, while blue squares indicate more snow. Large circles and squares indicate the most significant trends.[143] Areas south of 37°N latitude were excluded from the analysis because most of that area receives little snowfall. White areas above that line have inadequate data for this analysis.

The additional atmospheric moisture contributes to more overall precipitation in some areas, especially in much of the Northeast, Midwest, and Alaska. Over the past 50 years, precipitation and streamflow have increased in much of the Northeast and Midwest, with a reduction in drought duration and severity. Much of the Southeast and West has had reductions in precipitation and increases in drought severity and duration, especially in the Southwest.

In most areas of the country, the fraction of precipitation falling as rain versus snow has increased during the last 50 years. Despite this general shift from snow to rain, snowfalls

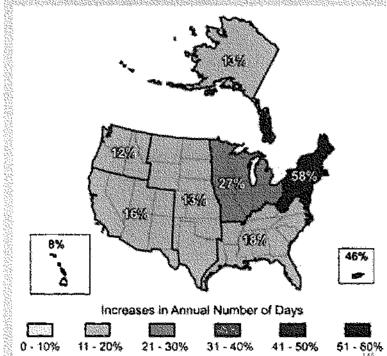
Observed Water-Related Changes During the Last Century		
Observed Change	**Direction of Change**	**Region Affected**
One to four week earlier peak streamflow due to earlier warming-driven snowmelt	Earlier	West and Northeast
Proportion of precipitation falling as snow	Decreasing	West and Northeast
Duration and extent of snow cover	Decreasing	Most of the United States
Mountain snow water equivalent	Decreasing	West
Annual precipitation	Increasing	Most of the United States
Annual precipitation	Decreasing	Southwest
Frequency of heavy precipitation events	Increasing	Most of the United States
Runoff and streamflow	Decreasing	Colorado and Columbia River Basins
Streamflow	Increasing	Most of East
Amount of ice in mountain glaciers	Decreasing	U.S. western mountains, Alaska
Water temperature of lakes and streams	Increasing	Most of the United States
Ice cover on lakes and rivers	Decreasing	Great Lakes and Northeast
Periods of drought	Increasing	Parts of West and East
Salinization of surface waters	Increasing	Florida, Louisiana
Widespread thawing of permafrost	Increasing	Alaska



Trends in end-of-summer drought as measured by the Palmer Drought Severity Index from 1958 to 2007 in each of 344 U.S. climate divisions. Hatching indicates significant trends.

along the downwind coasts of the Great Lakes have increased. Factors contributing to this increase include reduced ice cover due to warming, which lengthens the period of open water. In addition, cold air moving over relatively warm, open lake water induces strong evaporation, often causing heavy lake-effect snow. Heavy snowfall and snowstorm frequency have increased in many northern parts of the United States. In the South however, where temperatures are already marginal for heavy snowfall, climate warming has led to a reduction in heavy snowfall and snowstorm frequency. These trends suggest a northward shift in snowstorm occurrence.[68]

Increases in the Number of Days with Very Heavy Precipitation (1958 to 2007)



Updated from Groisman et al.[145]

The map shows the percentage increases in the average number of days with very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2007 for each region. There are clear trends toward more days with very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

Floods and droughts are likely to become more common and more intense as regional and seasonal precipitation patterns change, and rainfall becomes more concentrated into heavy events (with longer, hotter dry periods in between).

While it sounds counterintuitive, a warmer world produces both wetter and drier conditions. Even though total global precipitation increases, the regional and seasonal distribution of precipitation changes, and more precipitation comes in heavier rains (which can cause flooding) rather than light events. In the past century, averaged over the United States, total precipitation has increased by about 7 percent, while the heaviest 1 percent of rain events increased by nearly 20 percent.[68] This has been especially noteworthy in the Northeast, where the annual number of days with very heavy precipitation has increased most in the past 50 years, as shown in the adjacent figure. Flooding often occurs when heavy precipitation persists for weeks to months in large river basins. Such extended periods of heavy precipitation have also been increasing over the past century, most notably in the past two to three decades in the United States.[112]

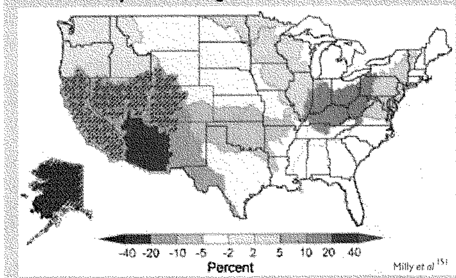
Observations also show that over the past several decades, extended dry periods have become more frequent in parts of the United States, especially the Southwest and the eastern United States.[146,147] Longer periods between rainfalls, combined with higher air temperatures, dry out soils and vegetation, causing drought.

For the future, precipitation intensity is projected to increase everywhere, with the largest increases occurring in areas in which average precipitation increases the most. For example, the Midwest and Northeast, where total precipitation is expected to increase the most, would also experience the largest increases in heavy precipitation events. The number of dry days between precipitation events is also projected to increase, especially in the more arid areas. Mid-continental areas and the Southwest are particularly threatened by future drought. The magnitude of the projected changes in extremes is expected to be greater than changes in averages, and hence detectable sooner.[49,68,90,142,148]

Precipitation and runoff are likely to increase in the Northeast and Midwest in winter and spring, and decrease in the West, especially the Southwest, in spring and summer.

Runoff, which accumulates as streamflow, is the amount of precipitation that is not evaporated, stored as snowpack or soil moisture, or filtered down to groundwater. The proportion of precipitation that runs off is determined by a variety of factors including temperature, wind speed, humidity, solar intensity at the ground, vegetation, and soil moisture. While runoff generally tracks precipitation, increases and decreases in precipitation do not necessarily lead to equal increases and decreases in runoff. For example, droughts cause soil moisture reductions that can reduce expected runoff until soil moisture is replenished. Conversely, water-saturated soils can generate floods with only moderate additional precipitation. During the last century, consistent increases in precipitation have been found in the Midwest and Northeast along with increased runoff.[149,150] Climate models consistently project that the East will experience increased runoff, while there will be substantial declines in the interior West, especially the Southwest. Projections for runoff in California and other parts of the West also show reductions, although less than in the interior West. In short, wet areas are projected to get wetter and dry areas drier. Climate models also consistently project heat-related summer soil moisture reductions in the middle of the continent.[115,142,146,149]

Projected Changes in Annual Runoff

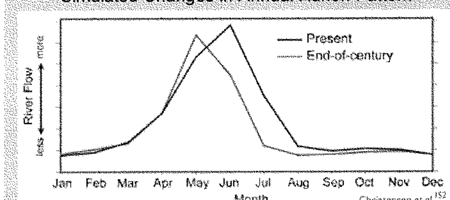


Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water-resource region. Colors indicate percentage changes in runoff. Hatched areas indicate greater confidence due to strong agreement among model projections. White areas indicate divergence among model projections. Results are based on emissions in between the lower and higher emissions scenarios.[91]

In areas where snowpack dominates, the timing of runoff will continue to shift to earlier in the spring and flows will be lower in late summer.

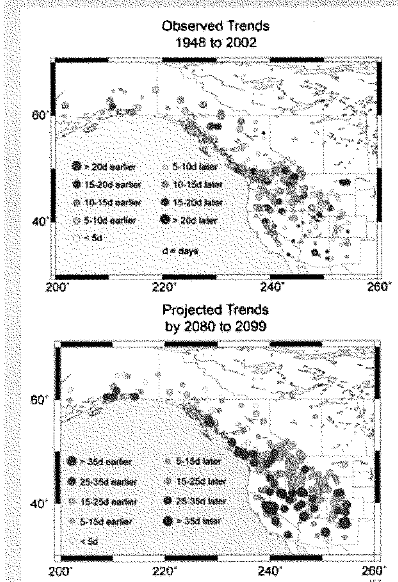
Large portions of the West and some areas in the Northeast rely on snowpack as a natural reservoir to hold winter precipitation until it later runs off as streamflow in spring, summer, and fall. Over the last 50 years, there have been widespread temperature-related reductions in snowpack in the West, with the largest reductions occurring in lower elevation mountains in the Northwest and California where snowfall occurs at temperatures close to the freezing point.[142,153] The Northeast has also experienced snowpack reductions during a similar period. Observations indicate a transition to more rain and less snow in both the West and Northeast in the last 50 years.[143,154-156] Runoff in snowmelt-dominated areas is occurring up to 20 days earlier in the West, and up to 14 days earlier in the Northeast.[157,158] Future projections for most snowmelt-dominated basins in the West consistently indicate earlier spring

Simulated Changes in Annual Runoff Pattern



General schematic of changes in the annual pattern of runoff for snowmelt-dominated streams. Compared to the historical pattern, runoff peak is projected to shift to earlier in the spring and late summer flows are expected to be lower. The above example is for the Green River, which is part of the Colorado River watershed.

Trends in Peak Streamflow Timing



Stewart et al[157]

Top map shows changes in runoff timing in snowmelt-driven streams from 1948 to 2002 with red circles indicating earlier runoff, and blue circles indicating later runoff. Bottom map shows projected changes in snowmelt-driven streams by 2080-2099, compared to 1951-1980, under a higher emissions scenario.[91]

runoff, in some cases up to 60 days earlier.[157,159] For the Northeast, projections indicate spring runoff will advance by up to 14 days.[150] Earlier runoff produces lower late-summer streamflows, which stress human and environmental systems through less water availability and higher water temperatures.[145] Scientific analyses to determine the causes of recent changes in snowpack, runoff timing, and increased winter temperatures have attributed these changes to human-caused climate change.[34,160,161]

Surface water quality and groundwater quantity will be affected by a changing climate.

Changes in water quality

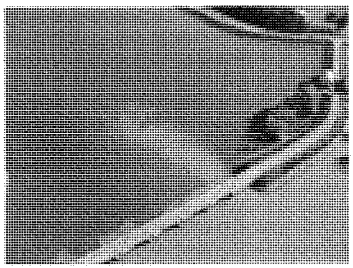
Increased air temperatures lead to higher water temperatures, which have already been detected in many streams, especially during low-flow periods. In lakes and reservoirs, higher water temperatures lead to longer periods of summer stratification (when surface and bottom waters do not mix). Dissolved oxygen is reduced in lakes, reservoirs, and rivers at higher temperatures. Oxygen is an essential resource for many living things, and its availability is reduced at higher temperatures both because the amount that can be dissolved in water is lower and because respiration rates of living things are higher. Low oxygen stresses aquatic animals such as coldwater fish and the insects and crustaceans on which they feed.[142] Lower oxygen levels also decrease the self-purification capabilities of rivers.

The negative effects of water pollution, including sediments, nitrogen from agriculture, disease pathogens, pesticides, herbicides, salt, and thermal pollution, will be amplified by observed and projected increases in precipitation intensity and longer periods when streamflows are low.[146] The U.S. Environmental Protection Agency expects the number of waterways considered "impaired" by water pollution to increase.[162] Heavy downpours lead to increased sediment in runoff and outbreaks of waterborne diseases.[163,164] Increases in pollution carried to lakes, estuaries, and the coastal ocean, especially when coupled with increased temperature, can result in blooms of harmful algae and bacteria. However, pollution has the potential of being diluted in regions that experience increased streamflow.

Water-quality changes during the last century were probably due to causes other than climate change, primarily changes in pollutants.[149]

Changes in groundwater

Many parts of the United States are heavily dependent on groundwater for drinking, residential, and agricultural water supplies.[164] How climate change will affect groundwater is not well known,

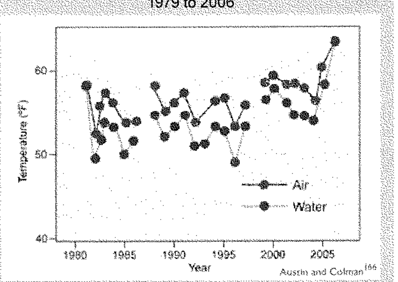


Heavy rain can cause sediments to become suspended in water, reducing its quality, as seen in the brown swath above in New York City's Ashokan reservoir following Hurricane Floyd in September 1999.

but increased water demands by society in regions that already rely on groundwater will clearly stress this resource, which is often drawn down faster than it can be recharged.[164] In many locations, groundwater is closely connected to surface water and thus trends in surface water supplies over time affect groundwater. Changes in the water cycle that reduce precipitation or increase evaporation and runoff would reduce the amount of water available for recharge. Changes in vegetation and soils that occur as temperature changes or due to fire or pest outbreaks are also likely to affect recharge by altering evaporation and infiltration rates. More frequent and larger floods are likely to increase groundwater recharge in semi-arid and arid areas, where most recharge occurs through dry streambeds after heavy rainfalls and floods.[142]

Sea-level rise is expected to increase saltwater intrusion into coastal freshwater aquifers, making some unusable without desalination.[146] Increased evaporation or reduced recharge into coastal aquifers exacerbates saltwater intrusion. Shallow groundwater aquifers that exchange water with streams are likely to be the most sensitive part of the groundwater system to climate change. Small reductions in groundwater levels can lead to large reductions in streamflow and increases in groundwater levels can increase streamflow.[165] Further, the interface between streams and groundwater is an important site for pollution removal by microorganisms. Their activity will change in response to increased temperature and increased or decreased streamflow as climate changes, and this will affect water quality. Like water quality, research on the impacts of climate change on groundwater has been minimal.[149]

Lake Superior Summer Air and Water Temperatures
1979 to 2006



The recent large jump in summer water temperature is related to the recent large reduction in ice cover (see *Midwest* region).

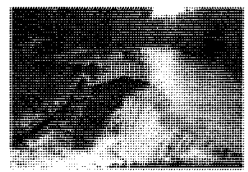
Climate change will place additional burdens on already stressed water systems.

In many places, the nation's water systems are already taxed due to aging infrastructure, population increases, and competition among water needs for farming, municipalities, hydropower, recreation, and ecosystems.[167-169] Climate change will add another factor to existing water management challenges, thus increasing vulnerability.[170] The U.S. Bureau of Reclamation has identified many areas in the West that are already at risk for serious conflict over water, even in the absence of climate change[171] (see figure next page).

Adapting to gradual changes, such as changes in average amounts of precipitation, is less difficult than adapting to changes in extremes. Where extreme events, such as droughts or floods, become more intense or more frequent with climate change, the economic and social costs of these events will increase.[172] Water systems have life spans of many years and are designed with spare capacity. These systems are thus able to cope with small changes in average conditions.[172] Water resource planning today considers a broad range of stresses and hence adaptation to climate change will be one factor among many in deciding what actions will be taken to minimize vulnerability.[172-174]

Rapid regional population growth

The U.S. population is estimated to have grown to more than 300 million people, nearly a 7 percent increase since the 2000 Census. Current Census Bureau projections are for this growth rate to continue, with the national population projected to reach 350 million by 2025 and 420 million by 2050. The highest rates of population growth to 2025 are projected to occur in areas such as the Southwest that are at risk for reductions in water supplies due to climate change.[167]



Damage to the city water system in Asheville, North Carolina, due to heavy rain in 2004.

Aging water infrastructure

The nation's drinking water and wastewater infrastructure is aging. In older cities, some buried water mains are over 100 years old and breaks of these lines are a significant problem. Sewer overflows resulting in the discharge of untreated wastewater also occur frequently. Heavier downpours will exacerbate existing problems in many cities, especially where stormwater catchments and sewers are combined. Drinking water and sewer infrastructure is very expensive to install and maintain. Climate change will present a new set of challenges for designing upgrades to the nation's water delivery and sewage removal infrastructure.[168]

Potential Water Supply Conflicts by 2025

The map shows regions in the West where water supply conflicts are likely to occur by 2025 based on a combination of factors including population trends and potential endangered species' needs for water. The red zones are where the conflicts are most likely to occur. This analysis does not factor in the effects of climate change, which is expected to exacerbate many of these already-identified issues.[171]

Existing water disputes across the country

Many locations in the United States are already undergoing water stress. The Great Lakes states are establishing an interstate compact to protect against reductions in lake levels and potential water exports. Georgia, Alabama, and Florida are in a dispute over water for drinking, recreation, farming, environmental purposes, and hydropower in the Apalachicola–Chattahoochee–Flint River system.[175,176]

The State Water Project in California is facing a variety of problems in the Sacramento Delta, including endangered species, saltwater intrusion, and potential loss of islands due to flood- or earthquake-caused levee failures.[177-182] A dispute over endangered fish in the Rio Grande has been ongoing for many years.[183] The Klamath River in Oregon and California has been the location of a multi-year disagreement over native fish, hydropower, and farming.[184,185] The Colorado River has been the site of numerous interstate quarrels over the last century.[186,187] Large, unquantified Native

American water rights challenge existing uses in the West (see *Southwest* region).[188] By changing the existing patterns of precipitation and runoff, climate change will add another stress to existing problems.

Changing water demands

Water demands are expected to change with increased temperatures. Evaporation is projected to increase over most of the United States as temperatures rise. Higher temperatures and longer dry periods are expected to lead to increased water demand for irrigation. This may be partially offset by more efficient use of water by plants due to rising atmospheric carbon dioxide. Higher temperatures are projected to increase cooling water withdrawals by electrical generating stations. In addition, greater cooling requirements in summer will increase electricity use, which in turn will require more cooling water for power plants. Industrial and municipal demands are expected to increase slightly.[146]

The past century is no longer a reasonable guide to the future for water management.

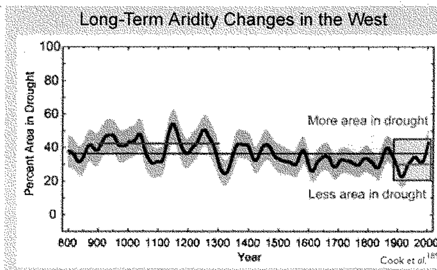
Water planning and management have been based on historical fluctuations in records of stream flows, lake levels, precipitation, temperature, and water demands. All aspects of water management including reservoir sizing, reservoir flood operations, maximum urban stormwater runoff amounts, and projected water demands have been based on these records. Water managers have proven adept at balancing supplies and demand through the significant climate variability of the past century.[142] Because climate change will significantly modify many aspects of the water cycle, the assumption of an unchanging climate is no longer appropriate for many aspects of water planning. Past assumptions derived from the historical record about supply and demand will need to be revisited for existing and proposed water projects.[142,151,174]

Drought studies that consider the past 1,200 years indicate that in the West, the last century was significantly wetter than most other centuries. Multi-decade "megadroughts" in the years 900 to 1300 were substantially worse than the worst droughts of the last century, including the Dust Bowl era. The causes of these events are only partially known; if they were to reoccur, they would clearly stress water management, even in the absence of climate change (see figure below).[97,149,189]

The intersection of substantial changes in the water cycle with multiple stresses such as population growth and competition for water supplies means that water planning will be doubly challenging. The ability to modify operational rules and water allocations is likely to be critical for the protection of infrastructure, for public safety, to ensure reliability of water delivery, and to protect the environment. There are, however, many institutional and legal barriers to such changes in both the short and long term.[190] Four examples:

- The allocation of the water in many interstate rivers is governed by compacts, international treaties, federal laws, court decrees, and other agreements that are difficult to modify.
- Reservoir operations are governed by "rule curves" that require a certain amount of space to be saved in a reservoir at certain times of

Long-Term Aridity Changes in the West



The black line shows the percentage of the area affected by drought (Palmer Drought Severity Index less than –1) in the West over the past 1,200 years. The red line indicates the average drought area in the years 900 to 1300. The blue horizontal line in the yellow box indicates the average during the period from 1900 to 2000, illustrating that the most recent period, during which population and water infrastructure grew rapidly in the West, was wetter than the long-term average (thin horizontal black line).[189] Droughts shown in the period 1100-1300 significantly exceed those that have occurred over the past 100 years.

year to capture a potential flood. Developed by the U.S. Army Corps of Engineers based on historical flood data, many of these rule curves have never been modified, and modifications might require Environmental Impact Statements.[151]

- In most parts of the West, water is allocated based on a "first in time means first in right" system, and because agriculture was developed before cities were established, large volumes of water typically are allocated to agriculture. Transferring agricultural rights to municipalities, even for short periods during drought, can involve substantial expense and time and can be socially divisive.

- Conserving water does not necessarily lead to a right to that saved water, thus creating a disincentive for conservation.

Total U.S. water diversions peaked in the 1980s, which implies that expanding supplies in many areas to meet new needs are unlikely to be a viable option, especially in arid areas likely to experience less precipitation. However, over the last 30 years, per capita water use has decreased significantly (due, for example, to more efficient technologies such as drip irrigation) and it is anticipated that per capita use will continue to decrease, thus easing stress.[149]

Highlights of Water-Related Impacts by Sector

Sector	Examples of Impacts
Human Health	Heavy downpours increase incidence of waterborne disease and floods, resulting in potential hazards to human life and health.
Energy Supply and Use	Hydropower production is reduced due to low flows in some regions. Power generation is reduced in fossil fuel and nuclear plants due to increased water temperatures and reduced cooling water availability.
Transportation	Floods and droughts disrupt transportation. Heavy downpours affect harbor infrastructure and inland waterways. Declining Great Lakes levels reduce freight capacity.
Agriculture and Forests	Intense precipitation can delay spring planting and damage crops. Earlier spring snowmelt leads to increased number of forest fires.
Ecosystems	Coldwater fish threatened by rising water temperatures. Some warmwater fish will expand ranges.

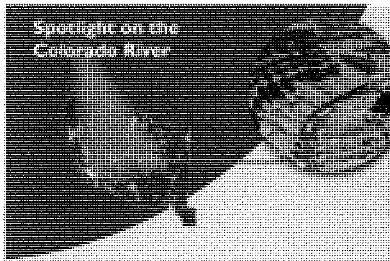
Adaptation: New York City Begins Planning for Climate Change

The New York City Department of Environmental Protection (DEP), the agency in charge of providing the city's drinking water and wastewater treatment, is beginning to alter its planning to take into account the effects of climate change – sea-level rise, higher temperatures, increases in extreme events, and changing precipitation patterns – on the city's water systems. In partnership with Columbia University, DEP is evaluating climate change projections, impacts, indicators, and adaptation and mitigation strategies.

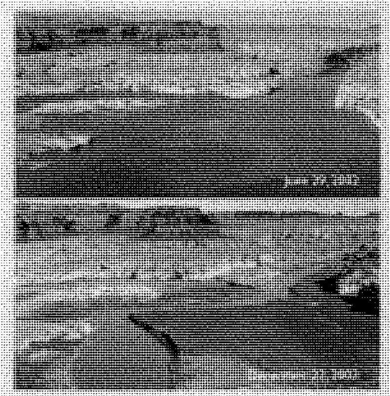
City planners have begun to address these issues by defining risks using probabilistic climate scenarios and considering potential adaptations that relate to operations/management, infrastructure, and policy. For example, DEP is examining the feasibility of relocating critical control systems to higher floors in low-lying buildings or to higher ground, building flood walls, and modifying design criteria to reflect changing hydrologic processes.

Important near-term goals of the overall effort include updating the existing 100-year flood elevations using climate model projections and identifying additional monitoring stations needed to track changes. DEP will also establish a system for reporting the impacts of extreme weather events on the City's watershed and infrastructure. In the immediate future, DEP will evaluate flood protection measures for three existing water pollution control plants that are scheduled for renovation.

Spotlight on the Colorado River



The Colorado River system supplies water to over 30 million people in the Southwest including Los Angeles, Phoenix, Las Vegas, and Denver. Reservoirs in the system, including the giant lakes Mead and Powell, were nearly full in 1999, with almost four times the annual flow of the river stored. By 2007, the system had lost approximately half of that storage after enduring the worst drought in 100 years of record keeping. Runoff was reduced due to low winter precipitation, and warm, dry, and windy spring seasons that substantially reduced snowpack.

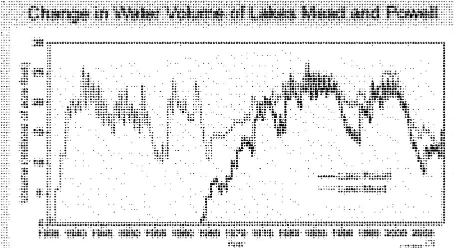


Matching photographs taken 18 months apart during the most serious period of recent drought show a significant decrease in Lake Powell.

Numerous studies over the last 30 years have indicated that the river is likely to experience reductions in runoff due to climate change. In addition, diversions from the river to meet the needs of cities and agriculture are approaching its average flow. Under current conditions, even without climate change, large year-to-year fluctuations in reservoir storage are possible. If reductions in flow projected to accompany global climate change occur, water managers will be challenged to satisfy all existing demands, let alone the increasing demands of a rapidly growing population.

Efforts are underway to address these challenges. In 2005, the Department of Interior's Bureau of Reclamation began a process to formalize operating rules for lakes Mead and Powell during times of low flows and to apportion limited water among the states.

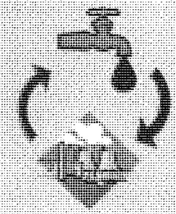
Change in Water Volume of Lakes Mead and Powell



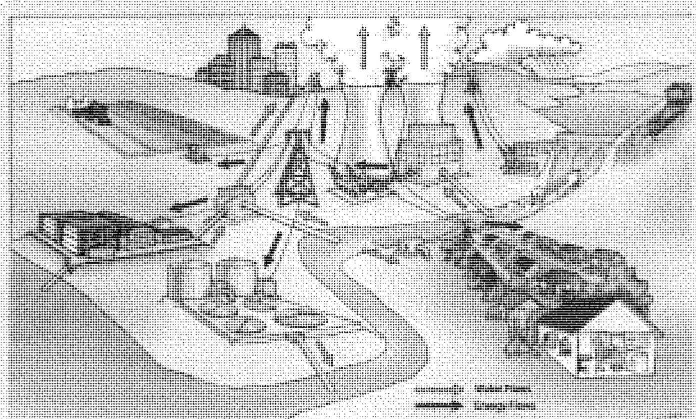
The filling of Lake Mead (green) was initiated in 1935, and that of Lake Powell (blue) in 1963. In 1999, the lakes were nearly full, but by 2007, the lakes had lost nearly half of their storage water after the worst drought in 100 years.

Water and Energy Connections

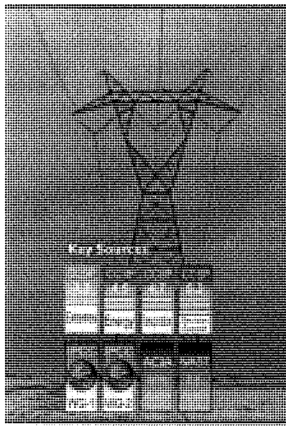
Water and energy are tightly interconnected; water systems use large amounts of energy, and energy systems use large amounts of water. Both are expected to be under increasing pressure in the future and both will be affected by a changing climate. In the energy sector, water is used directly for hydropower, and cooling water is critical for nearly all other forms of electrical power generation. Withdrawals of freshwater used to cool power plants that use heat to generate electricity are very large, nearly equaling the water withdrawn for irrigation. Water consumption by power plants is about 20 percent of all non-agricultural uses, or half that of all domestic use.



In the water sector, two very unusual attributes of water, significant weight due to its relatively high density, and high heat capacity, make water use energy intensive. Large amounts of energy are needed for pumping, heating, and treating drinking water and wastewater. Water supply and treatment consumes roughly 4 percent of the nation's power supply, and electricity accounts for about 75 percent of the cost of municipal water processing and transport. In California, 30 percent of all non-power plant natural gas is used for water-related activities. The energy required to provide water depends on its source (groundwater, surface water, desalinated water, treated wastewater, or recycled water), the distance the water is conveyed, the amount of water moved, and the local topography. Surface water often requires more treatment than groundwater. Desalination requires large amounts of energy to produce freshwater. Treated wastewater and recycled water (used primarily for agriculture and industry) require energy for treatment, but little energy for supply and conveyance. Conserving water has the dual benefit of conserving energy and potentially reducing greenhouse gas emissions if fossil fuels are the predominant source of that energy.



Water and energy are intimately connected. Water is used by the power generation sector for cooling, and energy is used by the water sector for pumping, drinking water treatment, and wastewater treatment. Without energy, there would be limited water distribution, and without water, there would be limited energy production.



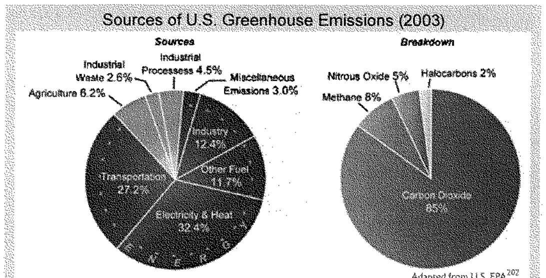
Energy Supply and Use

Key Messages:

Energy is at the heart of the global warming challenge.[3] It is humanity's production and use of energy that is the primary cause of global warming, and in turn, climate change will eventually affect our production and use of energy. The vast majority of U.S. greenhouse gas emissions, about 87 percent, come from energy production and use.[200]

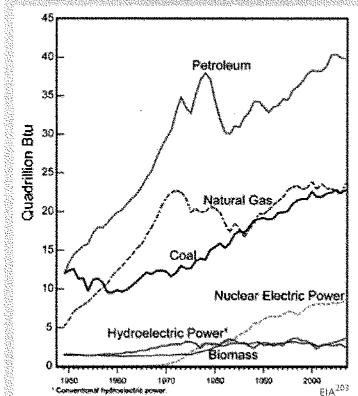
At the same time, other U.S. trends are increasing energy use: population shifts to the South, especially the Southwest, where air conditioning use is high, an increase in the square footage built per person, increased electrification of the residential and commercial sectors, and increased market penetration of air conditioning.[201]

Many of the effects of climate change on energy production and use in the United States are not well studied. Some of the effects of climate change, however, have clear implications for energy production and use. For instance, rising temperatures are expected to increase energy requirements for cooling and reduce energy requirements for heating.[164,201] Changes in precipitation have the potential to affect prospects for hydropower, positively or negatively.[201] Increases in hurricane intensity are likely to cause further disruptions to oil and gas operations in the Gulf, like those experienced in 2005 with Hurricane Katrina and in 2008 with Hurricane Ike.[201] Concerns about climate



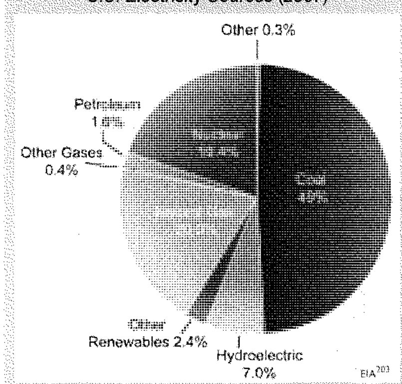
About 87 percent of U.S. greenhouse gas emissions come from energy production and use, as shown in the left pie chart. The right pie chart breaks down these emissions by greenhouse gas.

Primary Energy Consumption by Major Source (1949 to 2007)



U.S. energy supply is dominated by fossil fuels. Petroleum, the top source of energy shown above, is primarily used for transportation (70 percent of oil use). Natural gas is used in roughly equal parts to generate electricity, power industrial processes, and heat water and buildings. Coal is primarily used to generate electricity (91 percent of coal use). Nuclear power is used entirely for electricity generation.

U.S. Electricity Sources (2007)



Coal, natural gas, and nuclear power plants together account for about 90 percent of current U.S. electricity production.

change impacts will almost certainly alter perceptions and valuations of energy technology alternatives. These effects are very likely to be relevant for energy policies, decisions, and institutions in the United States, affecting courses of action and appropriate strategies for risk management.[201]

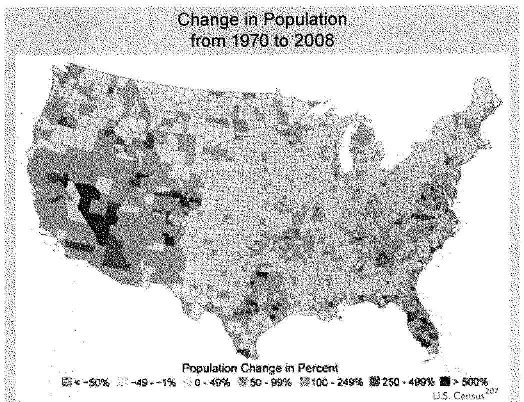
The overall scale of the national energy economy is very large, and the energy industry has both the financial and the managerial resources to be adaptive. Impacts due to climate change are likely to be most apparent at sub-national scales, such as regional effects of extreme weather events and reduced water availability, and effects of increased cooling demands on especially vulnerable places and populations.[204]

Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. The latter will result in significant increases in electricity use and higher peak demand in most regions.

Research on the effects of climate change on energy production and use has largely been limited to impacts on energy use in buildings. These studies have considered effects of global warming on energy requirements for heating and cooling in buildings in the United States.[205] They find that the demand for cooling energy increases from 5 to 20 percent per 1.8°F of warming, and the demand for heating energy drops by 3 to 15 percent per 1.8°F of warming.[205] These ranges reflect different assumptions about factors such as the rate of market penetration of improved building equipment technologies.[205]

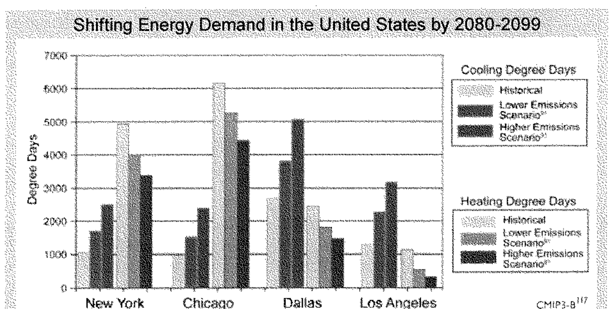
Studies project that temperature increases due to global warming are very likely to increase peak demand for electricity in most regions of the country.[205] An increase in peak demand can lead to a disproportionate increase in energy infrastructure investment.[205]

Since nearly all of the cooling of buildings is provided by electricity use, whereas the vast majority of the heating of buildings is provided by natural gas and fuel oil,[201,206] the projected changes imply increased demands for electricity. This is especially the case where climate change would result in significant increases in the heat index in summer, and where relatively little space cooling has been needed in the past, but demands are likely to increase in the future.[205] The increase in electricity demand is likely to be accelerated by population movements to the South and Southwest, which are regions of especially high per capita electricity use, due to demands for cooling in commercial buildings and households.[205] Because nearly half of the nation's electricity is currently generated from coal, these factors have the potential to increase total national carbon dioxide emissions in the absence of improved energy efficiency, development of non-carbon energy sources, and/or carbon capture and storage.[205]



The map above, showing percentage changes in county population between 1970 and 2008, graphically illustrates the large increases in places that require air conditioning. Areas with very large increases are shown in orange, red, and maroon. Some places had enormous growth, in the hundreds of thousands of people. For example, counties in the vicinity of South Florida, Atlanta, Los Angeles, Phoenix, Las Vegas, Denver, Dallas, and Houston all had very large increases.

Other effects of climate change on energy consumption are less clear, because little research has been done.[205] For instance, in addition to cooling, air conditioners also remove moisture from the air; thus the increase in humidity projected to accompany global warming is likely to increase electricity consumption by air conditioners even further.[205] As other examples, warming would increase the use of air conditioners in highway vehicles, and water scarcity in some regions has the potential to increase energy demands for water pumping. It is important to improve the information available about these other kinds of effects.



"Degree days" are a way of measuring the energy needed for heating and cooling by adding up how many degrees hotter or colder each day's average temperature is from 65°F over the course of a year. Colder locations have high numbers of heating degree days and low numbers of cooling degree days, while hotter locations have high numbers of cooling degree days and low numbers of heating degree days. Nationally, the demand for energy will increase in summer and decrease in winter. Cooling uses electricity while heating uses a combination of energy sources, so the overall effect nationally and in most regions will be an increased need for electricity. The projections shown in the chart are for late this century. The higher emissions scenario[91] used here is referred to as "even higher" on page 23.

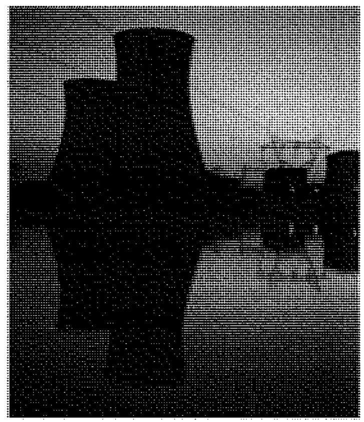
Energy production is likely to be constrained by rising temperatures and limited water supplies in many regions.

In some regions, reductions in water supply due to decreases in precipitation and/or water from melting snowpack are likely to be significant, increasing the competition for water among various sectors including energy production (see *Water Resources* sector).[191,208]

The production of energy from fossil fuels (coal, oil, and natural gas) is inextricably linked to the availability of adequate and sustainable supplies of water.[191,208] While providing the United States with the majority of its annual energy needs, fossil fuels also place a high demand on the nation's water resources in terms of both quantity and quality impacts.[191,208] Generation of electricity in thermal power plants (coal, nuclear, gas, or oil) is water intensive. Power plants rank only slightly behind irrigation in terms of freshwater withdrawals in the United States.[191]

There is a high likelihood that water shortages will limit power plant electricity production in many regions. Future water constraints on electricity production in thermal power plants are projected for Arizona, Utah, Texas, Louisiana, Georgia, Alabama, Florida, California, Oregon, and Washington state by 2025.[191] Additional parts of the United States could face similar constraints as a result of drought, growing populations, and increasing demand for water for various uses, at least seasonally.[209] Situations where the development of new power plants is being slowed down or halted due to inadequate cooling water are becoming more frequent throughout the nation.[191]

The issue of competition among various water uses is dealt with in more detail in the *Water Resources* sector. In connection with these issues and other regional water scarcity impacts, energy is likely to be needed to move and manage water. This is one of many examples of interactions among the impacts of climate change on various sectors that, in this case, affects energy requirements.



Nuclear, coal, and natural gas power plants require large amounts of water for cooling.[191]

In addition to the problem of water availability, there are issues related to an increase in water temperature. Use of warmer water reduces the efficiency of thermal power plant cooling technologies. And, warmer water discharged from power plants can alter species composition in aquatic ecosystems.[210] Large coal and nuclear plants have been limited in their operations by reduced river levels caused by higher temperatures and thermal limits on water discharge.[191]

The efficiency of thermal power plants, fossil or nuclear, is sensitive to ambient air and water temperatures; higher temperatures reduce power outputs by affecting the efficiency of cooling.[191] Although this effect is not large in percentage terms, even a relatively small change could have significant implications for total national electric power supply.[191] For example, an average reduction of 1 percent in electricity generated by thermal power plants nationwide would mean a loss of 25 billion kilowatt-hours per year,[211] about the amount of electricity consumed by 2 million Americans, a loss that would need to be supplied in some other way or offset through measures that improve energy efficiency.

Energy production and delivery systems are exposed to sea-level rise and extreme weather events in vulnerable regions.

Sea-level rise

A significant fraction of America's energy infrastructure is located near the coasts, from power plants, to oil refineries, to facilities that receive oil and gas deliveries.[191] Rising sea levels are likely to lead to direct losses, such as equipment damage from flooding or erosion, and indirect effects, such as the costs of raising vulnerable assets to higher levels or building new facilities farther inland, increasing transportation costs.[191] The U.S. East Coast and Gulf Coast have been identified as particularly vulnerable to sea-level rise because the land is relatively flat and also sinking in many places.[191]

Extreme events

Observed and projected increases in a variety of extreme events will have significant impacts on the energy sector. As witnessed in 2005, hurricanes can have a debilitating impact on energy infrastructure. Direct losses to the energy industry in 2005 are estimated at $15 billion,[191] with millions more in restoration and recovery costs. As one example, the Yscloskey Gas Processing Plant (located on the Louisiana coast) was forced to close for six months following Hurricane Katrina, resulting in lost revenues to the plant's owners and employees, and higher prices to consumers, as gas had to be procured from other sources.[191]

The impacts of an increase in severe weather are not limited to hurricane-prone areas. For example, rail transportation lines, which carry approximately two-thirds of the coal to the nation's power plants,[212] often follow riverbeds, especially in the Appalachian region.[191] More intense rainstorms, which have been observed and projected,[68,112] can lead to rivers flooding, which can "wash out" or degrade nearby railbeds and roadbeds.[191] This is also a problem in the Midwest, which experienced major flooding of the Mississippi River in 1993 and 2008.[213]

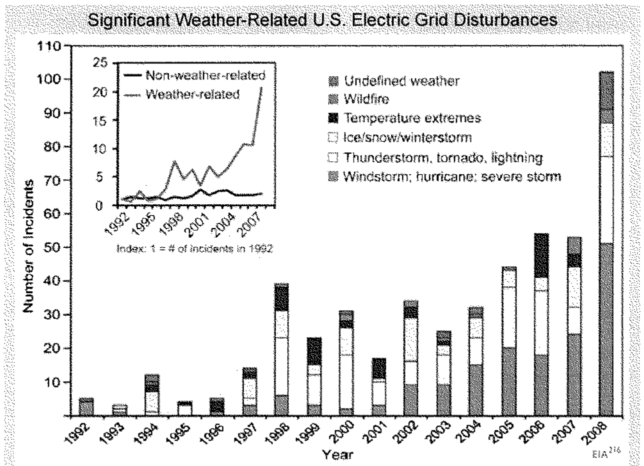
Development of new energy facilities could be restricted by siting concerns related to sea-level rise, exposure to extreme events, and increased capital costs resulting from a need to provide greater protection from extreme events.[191]

The electricity grid is also vulnerable to climate change effects, from temperature changes to severe weather events.[191] The most familiar example is

Regional Spotlight: Gulf Coast Oil and Gas

The Gulf Coast is home to the U.S. oil and gas industries, representing nearly 30 percent of the nation's crude oil production and approximately 20 percent of its natural gas production. One-third of the national refining and processing capacity lies on coastal plains adjacent to the Gulf of Mexico. Several thousand offshore drilling platforms, dozens of refineries, and thousands of miles of pipelines are vulnerable to damage and disruption due to sea-level rise and the high winds and storm surge associated with hurricanes and other tropical storms. For example, hurricanes Katrina and Rita halted all oil and gas production from the Gulf, disrupted nearly 20 percent of the nation's refinery capacity, and closed many oil and gas pipelines.[214] Relative sea-level rise in parts of the Gulf Coast region (Louisiana and East Texas) is projected to be as high as 2 to 4 feet by 2050 to 2100, due to the combination of global sea-level rise caused by warming oceans and melting ice and local land sinking.[191] Combined with onshore and offshore storm activity, this would represent an increased threat to this regional energy infrastructure. Some adaptations to these risks are beginning to emerge (see Adaptation box, page 58).

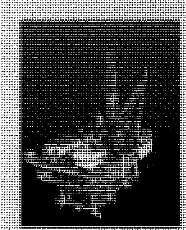
Offshore oil production is particularly susceptible to extreme weather events. Hurricane Ivan in 2004 destroyed seven platforms in the Gulf of Mexico, significantly damaged 24 platforms, and damaged 102 pipelines. Hurricanes Katrina and Rita in 2005 destroyed more than 100 platforms and damaged 558 pipelines. For example, Chevron's $250 million "Typhoon" platform was damaged beyond repair. Plans are being made to sink its remains to the seafloor.



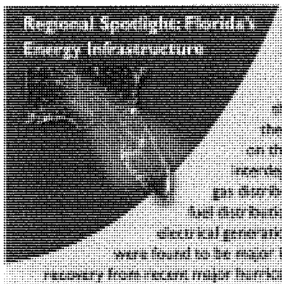
The number of incidents caused by extreme weather has increased tenfold since 1992. The portion of all events that are caused by weather-related phenomena has more than tripled from about 20 percent in the early 1990s to about 65 percent in recent years. The weather-related events are more severe, with an average of about 180,000 customers affected per event compared to about 100,000 for non-weather-related events (and 50,000 excluding the massive blackout of August 2003).[201] The data shown include disturbances that occurred on the nation's large-scale "bulk" electric transmission systems. Most outages occur in local distribution networks and are not included in the graph. Although the figure does not demonstrate a cause-effect relationship between climate change and grid disruption, it does suggest that weather and climate extremes often have important effects on grid disruptions. We do know that more frequent weather and climate extremes are likely in the future,[68] which poses unknown new risks for the electric grid.

Addressing Oil Infrastructure Vulnerabilities in the Gulf Coast

Port Fourchon, Louisiana, supports 75 percent of deepwater oil and gas production in the Gulf of Mexico, and its role in supporting oil production in the region is increasing. The Louisiana Offshore Oil Port, located about 20 miles offshore, links daily imports of 1 million barrels of oil and production of 300,000 barrels in the Gulf of Mexico to 50 percent of national refining capacity. One road, Louisiana Highway 1, connects Port Fourchon with the nation. It transports machinery, supplies, and workers and is the evacuation route for onshore and offshore workers. Responding to threats of storm surge and flooding, related in part to concerns about climate change, Louisiana is currently upgrading Highway 1, including elevating it above the 500-year flood level and building a higher bridge over Bayou LaFourche and the Boudreaux Canal.



Regional Spotlight: Florida's Energy Infrastructure



Florida's energy infrastructure is particularly vulnerable to sea-level rise and storm impacts. Most of the petroleum products consumed in Florida are delivered by barge to three ports, two on the east coast and one on the west coast. The interdependencies of natural gas distribution, transportation fuel distribution and delivery, and electrical generation and distribution were found to be major issues in Florida's recovery from recent major hurricanes.

effects of severe weather events on power lines, such as from ice storms, thunderstorms, and hurricanes. In the summer heat wave of 2006, for example, electric power transformers failed in several areas (including St. Louis, Missouri, and Queens, New York) due to high temperatures, causing interruptions of electric power supply. It is not yet possible to project effects of climate change on the grid, because so many of the effects would be more localized than current climate change models can depict; but, weather-related grid disturbances are recognized as a challenge for strategic planning and risk management.

Climate change is likely to affect some renewable energy sources across the nation, such as hydropower production in regions subject to changing patterns of precipitation or snowmelt.

Renewable sources currently account for about 9 percent of electricity production in the United States.[203] Hydroelectric power is by far the largest renewable contributor to electricity generation,[191] accounting for about 7 percent of total U.S. electricity.[218] Like many things discussed in this report, renewable energy resources have strong interrelationships with climate change; using renewable energy can reduce the magnitude of climate change, while climate change can affect the prospects for using some renewable energy sources.

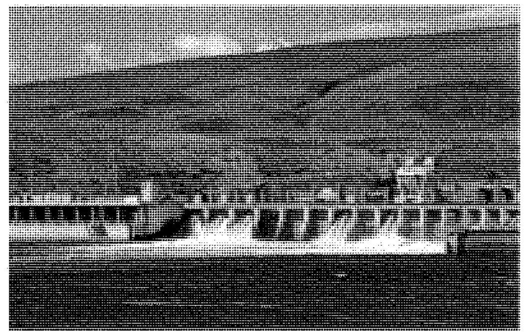
Hydropower is a major source of electricity in some regions of the United States, notably in the Northwest.[191] It is likely to be significantly affected by climate change in regions subject to reduced precipitation and/or water from melting snowpack. Significant changes are already being detected in the timing and amount of streamflows in many western rivers,[164] consistent with the predicted effects of global warming. More precipitation coming as rain rather than snow, reduced snowpack, earlier peak runoff, and related effects are beginning to affect hydropower availability.[164]

Hydroelectric generation is very sensitive to changes in precipitation and river discharge. For example, every 1 percent decrease in precipitation results in a 2 to 3 percent drop in streamflow;[219] every 1 percent decrease in streamflow in the Colorado River Basin results in a 3 percent drop in power generation.[191] Such magnifying sensitivities occur because water flows through multiple power plants in a river basin.[191]

Climate impacts on hydropower occur when either the total amount or the timing of runoff is altered, such as when natural water storage in snowpack and glaciers is reduced under hotter conditions. Glaciers, snowpack, and their associated runoff are already declining in the West, and larger declines are projected.[164]

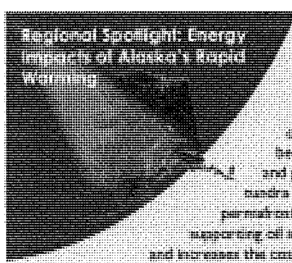
Hydropower operations are also affected by changes to air temperatures, humidity, or wind patterns due to climate change.[191] These variables cause changes in water quantity and quality, including water temperature. Warmer air and water generally increase the evaporation of water from the surface

of reservoirs, reducing the amount of water available for power production and other uses. Huge reservoirs with large surface areas, located in arid, sunny parts of the country, such as Lake Mead (located on Arizona-Nevada border on the Colorado River), are particularly susceptible to increased evaporation due to warming, meaning less water will be available for all uses, including hydropower.[191] And, where hydropower dams flow into waterways that support trout, salmon or other coldwater fisheries, warming of reservoir releases might have detrimental consequences that require changes in operations that reduce power production.[191] Such impacts will increasingly translate into competition for water resources.



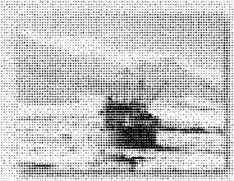
Hydroelectric dam in the Northwest

Climate change is also likely to affect other renewable energy sources. For example, changing cloud cover affects solar energy resources, changes in winds affect wind power, and temperature and water availability affect biomass production (particularly related to water requirements for biofuels).[191] The limited research to date on these important issues does not support firm conclusions about where such impacts would occur and how significant they would be.[205] This is an area that calls for much more study (see *An Agenda for Climate Impacts Science* section, Recommendation 2).



Regional Spotlight: Energy Impacts of Alaska's Rapid Warming

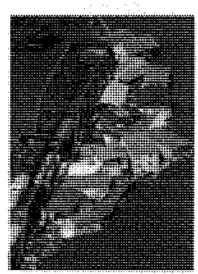
Significant impacts of warming on the energy sector can already be observed in Alaska, where temperatures have risen about twice as much as the rest of the nation. In Alaska, frozen ground and ice roads are an important means of winter travel, and warming has resulted in a much shorter cold season. Impacts on the oil and natural gas industries on Alaska's North Slope have been one of the results. For example, the season during which oil and gas exploration and extraction equipment can be operated on the tundra has been shortened due to warming. In addition, the thawing of permafrost, on which buildings, pipelines, airfields, and coastal installations supporting oil and gas development are located, adversely affects these structures and increases the cost of maintaining them.



Different energy impacts are expected in the marine environment as sea ice continues to retreat and thin. These trends are expected to improve shipping accessibility, including oil and gas transport by sea, around the margins of the Arctic Basin, at least in the summer. The improved accessibility, however, will not be uniform throughout the different regions. Offshore oil exploration and extraction might benefit from less extensive and thinner sea ice, although equipment will have to be designed to withstand increased wave forces and ice movement.

Transportation

The U.S. transport sector is a significant source of greenhouse gases, accounting for 27 percent of U.S. emissions.[221] While it is widely recognized that emissions from transportation have a major impact on climate, climate change will also have a major impact on transportation.



Buildings and debris float up against a railroad bridge on the Cedar River during record flooding in June 2008, in Cedar Rapids, Iowa.

Climate change impacts pose significant challenges to our nation's multimodal transportation system and cause disruptions in other sectors across the economy. For example, major flooding in the Midwest in 1993 and 2008 restricted regional travel of all types, and disrupted freight and rail shipments across the country, such as those bringing coal to power plants and chlorine to water treatment systems. The U.S. transportation network is vital to the nation's economy, safety, and quality of life.

Extreme events present major challenges for transportation, and such events are becoming more frequent and intense. Historical weather patterns are no longer a reliable predictor of the future.[222] Transportation planners have not typically accounted for climate change in their long-term planning and project development. The longevity of transportation infrastructure, the long-term nature of climate change, and the potential impacts identified by recent studies warrant serious attention to climate change in planning new or rehabilitated transportation systems.[223]

The strategic examination of national, regional, state, and local networks is an important step toward understanding the risks posed by climate change. A range of adaptation responses can be employed to reduce risks through redesign or relocation of infrastructure, increased redundancy of critical services, and operational improvements. Adapting to climate change is an evolutionary process. Through adoption of longer planning horizons, risk management, and adaptive responses, vulnerable transportation infrastructure can be made more resilient.[215]

Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, roads, rail lines, and tunnels.

Sea-level rise

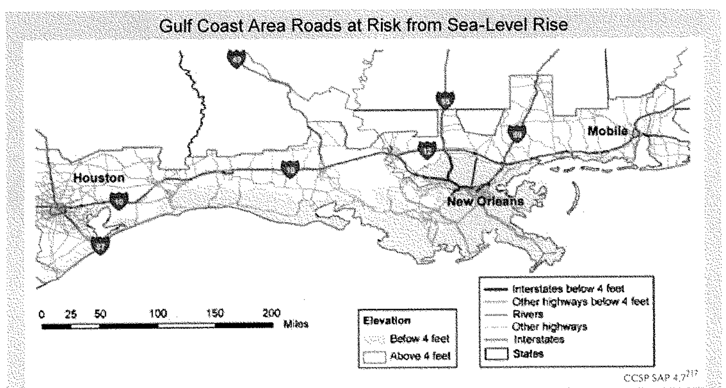
Transportation infrastructure in U.S. coastal areas is increasingly vulnerable to sea-level rise. Given the high population density near the coasts, the potential exposure of transportation infrastructure to flooding is immense. Population swells in these areas during the summer months because beaches are very important tourist destinations.[222]

In the Gulf Coast area alone, an estimated 2,400 miles of major roadway and 246 miles of freight rail lines are at risk of permanent flooding within 50 to 100 years as global warming and land subsidence (sinking) combine to produce an anticipated relative sea-level rise in the range of 4 feet.[217] Since the Gulf Coast region's transportation network is interdependent and relies on minor roads and other low-lying infrastructure, the risks of service disruptions due to sea-level rise are likely to be even greater.[217]

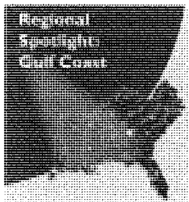
Coastal areas are also major centers of economic activity. Six of the nation's top 10 freight gateways (measured by the value of shipments) will be threatened by sea-level rise.[222] Seven of the 10 largest ports (by tons of traffic) are located on the Gulf Coast.[222] The region is also home to the U.S. oil and gas industry, with its offshore drilling platforms, refineries, and pipelines. Roughly two-thirds of all U.S. oil imports are transported through this region[224] (see *Energy* sector). Sea-level rise would potentially affect commercial transportation activity valued in the hundreds of billions of dollars annually through inundation of area roads, railroads, airports, seaports, and pipelines.[217]

Storm surge

More intense storms, especially when coupled with sea-level rise, will result in far-reaching and damaging storm surges. An estimated 60,000 miles of coastal highway are already exposed to periodic flooding from coastal storms and high waves.[222] Some of these highways currently serve as evacuation routes during hurricanes and other coastal storms, and these routes could become seriously compromised in the future.



Within 50 to 100 years, 2,400 miles of major roadway are projected to be inundated by sea-level rise in the Gulf Coast region. The map shows roadways at risk in the event of a sea-level rise of about 4 feet, within the range of projections for this region in this century under medium- and high-emissions scenarios.[91] In total, 24 percent of interstate highway miles and 28 percent of secondary road miles in the Gulf Coast region are at elevations below 4 feet.[217]



Sea-level rise, combined with high rates of subsidence in some areas, will make much of the existing infrastructure more prone to frequent or permanent inundation: 27 percent of the major roads, 9 percent of the rail lines, and 72 percent of the ports in the area shown on the map on the previous page are built on land at or below 4 feet in elevation, a level within the range of projections for relative sea-level rise in this region in this century. Increased storm intensity may lead to increased service disruption and infrastructure damage. More than half of the area's major highways (64 percent of interstates, 57 percent of arterials), almost half of the rail miles, 29 airports, and virtually all of the ports, are below 23 feet in elevation and subject to flooding and damage due to hurricane storm surge. These factors merit consideration in today's transportation decisions and planning processes.

Coastal areas are projected to experience continued development pressures as both retirement and tourist destinations. Many of the most populous counties of the Gulf Coast, which already experience the effects of tropical storms, are expected to grow rapidly in the coming decades.[222] This growth will generate demand for more transportation infrastructure and services, challenging transportation planners to meet the demand, address current and future flooding, and plan for future conditions.[223]

Land

More frequent inundation and interruptions in travel on coastal and low-lying roadways and rail lines due to storm surge are projected, potentially requiring changes to minimize disruptions. More frequent evacuations due to severe storm surges are also likely. Across the United States, many coastal cities have subways, tunnels, parking lots, and other transportation infrastructure below ground. Underground tunnels and other low-lying infrastructure will experience more frequent and severe flooding. Higher sea levels and storm surges will also erode road base and undermine bridge supports. The loss of coastal wetlands and barrier islands will lead to further coastal erosion due to the loss of natural protection from wave action.

Water

Impacts on harbor infrastructure from wave damage and storm surges are projected to increase. Changes will be required in harbor and port facilities to accommodate higher tides and storm surges. There will be reduced clearance under some waterway bridges for boat traffic. Changes in the navigability of channels are expected; some will become more accessible (and extend farther inland) because of deeper waters, while others will be restricted because of changes in sedimentation rates and sandbar locations. In some areas, waterway systems will become part of open water as barrier islands disappear. Some channels are likely to have to be dredged more frequently as has been done across large open-water bodies in Texas.[222]

With the potential for significant sea-level rise estimated under continued high levels of emissions, the combined effects of sea-level rise and storm surge are projected to increase the frequency of flooding. What is currently called a 100-year storm is projected to occur as often as every 10 years by late this century. Portions of lower Manhattan and coastal areas of Brooklyn, Queens, Staten Island, and Nassau County, would experience a marked increase in flooding frequency. Much of the critical transportation infrastructure, including tunnels, subways, and airports, lies well within the range of projected storm surge and would be flooded during such events.

Air

Airports in coastal cities are often located adjacent to rivers, estuaries, or open ocean. Airport runways in coastal areas face inundation unless effective protective measures are taken. There is the potential for closure or restrictions for several of the nation's busiest airports that lie in coastal zones, affecting service to the highest density populations in the United States.

Flooding from increasingly intense downpours will increase the risk of disruptions and delays in air, rail, and road transportation, and damage from mudslides in some areas.

Heavy downpours have already increased substantially in the United States; the heaviest 1 percent of precipitation events increased by 20 percent, while total precipitation increased by only 7 percent over the past century.[112] Such intense precipitation is likely to increase the frequency and severity of events such as the Great Flood of 1993, which caused catastrophic flooding along 500 miles of the Mississippi and Missouri river system, paralyzing surface transportation systems, including rail, truck, and marine traffic. Major east-west traffic was halted for roughly six weeks in an area stretching from St. Louis, Missouri, west to Kansas City, Missouri and north to Chicago, Illinois, affecting one-quarter of all U.S. freight, which either originated or terminated in the flood-affected region.[222]

The June 2008 Midwest flood was the second record-breaking flood in the past 15 years. Dozens of levees were breached or overtopped in Iowa, Illinois, and Missouri, flooding huge areas, including nine square miles in and around Cedar Rapids, Iowa. Numerous highway and rail bridges were impassable due to flooding of approaches and transport was shut down along many stretches of highway, rail lines, and normally navigable waterways.

Planners have generally relied on weather extremes of the past as a guide to the future, planning, for example, for a "100-year flood," which is now likely to come more frequently as a result of climate change. Historical analysis of weather data has thus become less reliable as a forecasting tool. The accelerating changes in climate make it more difficult to predict the frequency and intensity of weather events that can affect transportation.[222]

Land

The increase in heavy precipitation will inevitably cause increases in weather-related accidents, delays, and traffic disruptions in a network already challenged by increasing congestion.[215] There will be increased flooding of evacuation routes, and construction activities will be disrupted. Changes in rain, snowfall, and seasonal flooding will impact safety and maintenance operations on the nation's roads and railways. For example, if more precipitation falls as rain rather than snow in winter and spring, there will be an increased risk of landslides, slope failures, and floods from the runoff, causing road closures as well as the need for road repair and reconstruction[222] (see *Water Resources* sector).

Increased flooding of roadways, rail lines, and underground tunnels is expected. Drainage systems will be overloaded more frequently and severely, causing backups and street flooding. Areas where flooding is already common will face more frequent and severe problems. For example, Louisiana Highway 1, a critical link in the transport of oil from the Gulf of Mexico, has recently experienced increased flooding, prompting authorities to elevate the road (see Adaptation Box page 58).[217] Increases in road washouts, damage to railbed support structures, and landslides and mudslides that damage roads and other infrastructure are expected. If soil moisture levels become too high, the structural integrity of roads, bridges, and tunnels, which in some cases are already under age-related stress and in need of repair, could be compromised. Standing water will have adverse impacts on road base. For example, damage due to long term submersion of roadways in Louisiana was estimated to be $50 million for just 200 miles of state-owned highway. The Louisiana Department of Transportation and Development noted that a total of 1,800 miles of roads were under water for long periods, requiring costly repairs.[217] Pipelines are likely to be damaged because intense precipitation can cause the ground to sink underneath the pipeline; in shallow river-

Adaptation: Climate Proofing a Road

Completion of a road around the 42-square mile island of Kosrae in the U.S.-affiliated Federated States of Micronesia provides a good example of adaptation to climate change. A road around the island's perimeter existed, except for a 10-mile gap. Filling this gap would provide all-weather land access to a remote village and allow easier access to the island's interior.

In planning this new section of road, authorities decided to "climate-proof" it against projected increases in heavy downpours and sea-level rise. This led to the section of road being placed higher above sea level and with an improved drainage system to handle the projected heavier rainfall. While there were additional capital costs for incorporating this drainage system, the accumulated costs, including repairs and maintenance, would be lower after about 15 years, equating to a good rate of return on investment. Adding the improved drainage system to roads that are already built is more expensive than on new construction, but still has been found to be cost effective.[223]

beds, pipelines are more exposed to the elements and can be subject to scouring and shifting due to heavy precipitation.[217]

Water

Facilities on land at ports and harbors will be vulnerable to short term flooding from heavy downpours, interrupting shipping service. Changes in silt and debris buildup resulting from extreme precipitation events will affect channel depth, increasing dredging costs. The need to expand stormwater treatment facilities, which can be a significant expense for container and other terminals with large impermeable surfaces, will increase.

Air

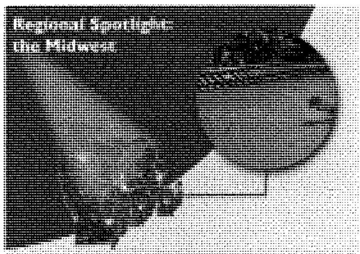
Increased delays due to heavy downpours are likely to affect operations, causing increasing flight delays and cancellations.[222] Stormwater runoff that exceeds the capacity of collection and drainage systems will cause flooding, delays, and airport closings. Heavy downpours will affect the structural integrity of airport facilities, such as through flood damage to runways and other infrastructure. All of these impacts have implications for emergency evacuation planning, facility maintenance, and safety.[222]

The increase in extreme heat will limit some transportation operations and cause pavement and track damage. Decreased extreme cold will provide some benefits such as reduced snow and ice removal costs.

Land

Longer periods of extreme heat in summer can damage roads in several ways, including softening of asphalt that leads to rutting from heavy traffic.[164] Sustained air temperature over 90°F is a significant threshold for such problems (see maps page 34). Extreme heat can cause deformities in rail tracks, at minimum resulting in speed restrictions and, at worst, causing derailments. Air temperatures above 100°F can lead to equipment failure (see maps page 90). Extreme heat also causes thermal expansion of bridge joints, adversely affecting bridge operations and increasing maintenance costs. Vehicle overheating and tire deterioration are additional concerns.[222] Higher temperatures will also increase refrigeration needs for goods during transport, particularly in the South, raising transportation costs.[217]

Increases in very hot days and heat waves are expected to limit construction activities due to health and safety concerns for highway workers. Guid-



An example of intense precipitation affecting transportation infrastructure was the record-breaking 24-hour rainstorm in July 1996, which resulted in flash flooding in Chicago and its suburbs, with major impacts. Extensive travel delays occurred on metropolitan highways and railroads, and streets and bridges were damaged. Commuters were unable to reach Chicago for up to three days, and more than 300 freight trains were delayed or rerouted.

The June 2008 Midwest floods caused I-80 in eastern Iowa to be closed for more than five days, disrupting major east-west shipping routes for trucks and the east-west rail lines through Iowa. These floods exemplify the kind of extreme precipitation events and their direct impacts on transportation that are likely to become more frequent in a warming world. These extremes create new and more difficult problems that must be addressed in the design, construction, rehabilitation, and operation of the nation's transportation infrastructure.

ance from the U.S. Occupational Safety and Health Administration states that concern for heat stress for moderate to heavy work begins at about 80°F as measured by an index that combines temperature, wind, humidity, and direct sunlight. For dry climates, such as Phoenix and Denver, National Weather Service heat indices above 90°F might allow work to proceed, while higher humidity areas such as New Orleans or Miami should consider 80 to 85°F as an initial level for work restrictions.[227] These trends and associated impacts will be exacerbated in many places by urban heat island effects (see *Human Health* and *Society* sectors).

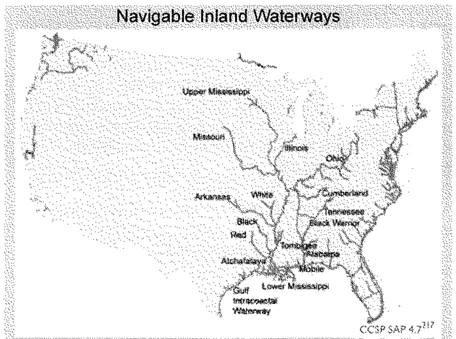
Wildfires are projected to increase, especially in the Southwest (see *Southwest* region), threatening communities and infrastructure directly and bringing about road and rail closures in affected areas.

In many northern states, warmer winters will bring about reductions in snow and ice removal costs, lessen adverse environmental impacts from the use of salt and chemicals on roads and bridges, extend the construction season, and improve the mobility and safety of passenger and freight travel through reduced winter hazards. On the other hand, more freeze-thaw conditions are projected to occur in northern states, creating frost heaves and potholes on road and bridge surfaces and resulting in load restrictions on certain roads to minimize the damage. With the expected earlier onset of seasonal warming, the period of springtime load restrictions might be reduced in some areas, but it is likely to expand in others with shorter winters but longer thaw seasons. Longer construction seasons will be a benefit in colder locations.[222]

Water

Warming is projected to mean a longer shipping season but lower water levels for the Great Lakes and St. Lawrence Seaway. Higher temperatures, reduced lake ice, and increased evaporation are expected to combine to produce lower water levels as climate warming proceeds (see *Midwest* region). With lower lake levels, ships will be unable to carry as much cargo and hence shipping costs will increase. A recent study, for example, found that the projected reduction in Great Lakes water levels would result in an estimated 13 to 29 percent increase in shipping costs for Canadian commercial navigation by 2050, all else remaining equal.[222]

If low water levels become more common because of drier conditions due to climate change, this could create problems for river traffic, reminiscent of the stranding of more than 4,000 barges on the Mississippi River during the drought in 1988. Freight movements in the region could be seriously impaired, and extensive dredging could be required to keep shipping channels open. On the other hand, a longer shipping season afforded by a warmer climate could offset some of the resulting adverse economic effects.



Inland waterways are an important part of the transportation network in various parts of the United States. For example, these waterways provide 20 states with access to the Gulf of Mexico.[217] As conditions become drier, these main transportation pathways are likely to be adversely affected by the resulting lower water levels, creating problems for river traffic. Names of navigable rivers are shown above.

In cold areas, the projected decrease in very cold days will mean less ice accumulation on vessels, decks, riggings, and docks; less ice fog; and fewer ice jams in ports.[222]

Air

Rising temperatures will affect airport ground facilities, runways in particular, in much the same way they affect roads. Airports in some areas are likely to benefit from reduction in the cost of snow and ice removal and the impacts of salt and chemical use, though some locations have seen increases in snowfall. Airlines could benefit from reduced need to de-ice planes.

More heat extremes will create added operational difficulties, for example, causing greater energy consumption by planes on the ground. Extreme heat also affects aircraft lift; because hotter air is less dense, it reduces the lift produced by the wing and the thrust produced by the engine – problems exacerbated at high altitudes and high temperatures. As a result, planes need to take off faster, and if runways are not sufficiently long for aircraft to build up enough speed to generate lift, aircraft weight must be reduced. Thus, increases in extreme heat will result in payload restrictions, could cause flight cancellations and service disruptions at affected airports, and could require some airports to lengthen runways. Recent hot summers have seen flights cancelled due to heat, especially in high altitude locations. Economic losses are expected at affected airports. A recent illustrative analysis projects a 17 percent reduction in freight carrying capacity for a single Boeing 747 at the Denver airport by 2030 and a 9 percent reduction at the Phoenix airport due to increased temperature and water vapor.[222]

Drought

Rising air temperatures increase evaporation, contributing to dry conditions, especially when accompanied by decreasing precipitation. Even where total annual precipitation does not decrease, precipitation is projected to become less frequent in many parts of the country.[68] Drought is expected to be an increasing problem in some regions; this, in turn, has impacts on transportation. For example, increased susceptibility to wildfires during droughts could threaten roads and other transportation infrastructure directly, or cause road closures due to fire threat or reduced visibility such as has occurred in Florida and California in recent years. There is also increased susceptibility to mudslides in areas deforested by wildfires. Airports could suffer from decreased visibility due to wildfires. River transport is seriously affected by drought, with reductions in the routes available, shipping season, and cargo carrying capacity.

Increased intensity of strong hurricanes would lead to more evacuations, infrastructure damage and failure, and transportation interruptions.

More intense hurricanes in some regions are a projected effect of climate change. Three aspects of tropical storms are relevant to transportation: precipitation, winds, and wind-induced storm surge. Stronger hurricanes have longer periods of intense precipitation, higher wind speeds (damage increases exponentially with wind speed[228]), and higher storm surge and waves. Transportation planners, designers, and operators may need to adopt probabilistic approaches to developing transportation projects rather than relying on standards and the deterministic approaches of the past. The uncertainty associated with projecting impacts over a 50- to 100-year time period makes risk management a reasonable approach for realistically incorporating climate change into decision making and investment.[215]

Land

There will be a greater probability of infrastructure failures such as highway and rail bridge decks being displaced and railroad tracks being washed away. Storms leave debris on roads and rail lines, which can damage the infrastructure and interrupt travel and shipments of goods. In Louisiana, the Department of Transportation and Development spent $74 million for debris removal alone in the wake of hurricanes Katrina and Rita. The Mississippi Department of Transportation expected to spend in excess of $1 billion to replace the Biloxi and Bay St. Louis bridges, repair other portions of roadway, and remove debris. As of June 2007, more than $672 million had been spent.

There will be more frequent and potentially more extensive emergency evacuations. Damage to signs, lighting fixtures, and supports will increase. The lifetime of highways that have been exposed to flooding is expected to decrease. Road and rail infrastructure for passenger and freight services are likely to face increased flooding by strong hurricanes. In the Gulf Coast, more than one-third of the rail miles are likely to flood when subjected to a storm surge of 18 feet.[217]

Spotlight on Hurricane Katrina

Hurricane Katrina was one of the most destructive and expensive natural disasters in U.S. history, claiming more than 1,800 lives and causing an estimated $134 billion in damage.[218,219] It also seriously disrupted transportation systems as key highway and railroad bridges were heavily damaged or destroyed, necessitating rerouting of traffic and placing increased strain on other routes, particularly other rail lines. Replacement of major infrastructure took from months to years. The CSX Gulf Coast line was re-opened after five months and $250 million in reconstruction costs, while the Biloxi-Ocean Springs Bridge took more than two years to reopen. Barge shipping was halted, as was grain export out of the Port of New Orleans, the nation's largest site of grain exports. The extensive oil and gas pipeline network was shut down by the loss of electrical power, producing shortages of natural gas and petroleum products. Total recovery costs for the roads, bridges, and utilities as well as debris removal have been estimated at $15 billion to $18 billion.[221]

Redundancies in the transportation system, as well as the storm timing and track, helped keep the storm from having major or long-lasting impacts on national-level freight flows. For example, truck traffic was diverted from the collapsed bridge that carries highway I-10 over Lake Pontchartrain to highway I-12, which parallels I-10 well north of the Gulf Coast. The primary north-south highways that connect the Gulf Coast with major inland transportation hubs were not damaged and were open for nearly full commercial freight movement within days. The railroads were able to route some traffic not bound directly for New Orleans through Memphis and other Midwest rail hubs. While a disaster of historic proportions, the effects of Hurricane Katrina could have been even worse if not for the redundancy and resilience of the transportation network in the area.

Hurricane Katrina damage to bridge

Water
All aspects of shipping are disrupted by major storms. For example, freight shipments need to be diverted from the storm region. Activities at offshore drilling sites and coastal pumping facilities are generally suspended and extensive damage to these facilities can occur, as was amply demonstrated during the 2005 hurricane season. Refineries and pipelines are also vulnerable to damage and disruption due to the high winds and storm surge associated with hurricanes and other tropical storms (see *Energy* sector). Barges that are unable to get to safe harbors can be destroyed or severely damaged. Waves and storm surge will damage harbor infrastructure such as cranes, docks, and other terminal facilities. There are implications for emergency evacuation planning, facility maintenance, and safety management.

Air
More frequent interruptions in air service and airport closures can be expected. Airport facilities including terminals, navigational equipment, perimeter fencing, and signs are likely to sustain increased wind damage. Airports are frequently located in low-lying areas and can be expected to flood with more intense storms. As a response to this vulnerability, some airports, such as LaGuardia in New York City, are already protected by levees. Eight airports in the Gulf Coast region of Louisiana and Texas are located in historical 100-year flood plains; the 100-year flood events will be more frequent in the future, creating the likelihood of serious costs and disruption.[217]

Arctic warming will continue to reduce sea ice, lengthening the ocean transport season, but also resulting in greater coastal erosion due to waves. Permafrost thaw in Alaska will damage infrastructure. The ice road season will become shorter.

Special issues in Alaska
Warming has been most rapid in high northern regions. As a result, Alaska is warming at twice the rate of the rest of the nation, bringing both major opportunities and major challenges. Alaska's transportation infrastructure differs sharply from that of the lower 48 states. Although Alaska is twice the size of Texas, its population and road mileage are more like Vermont's. Only 30 percent of Alaska's roads are paved. Air travel is much more common than in other states. Alaska has 84 commercial airports and more than 3,000 airstrips, many of which are the only means of transport for rural communities. Unlike other states, over much of Alaska, the land is generally more accessible in winter, when the ground is frozen and ice roads and bridges formed by frozen rivers are available.

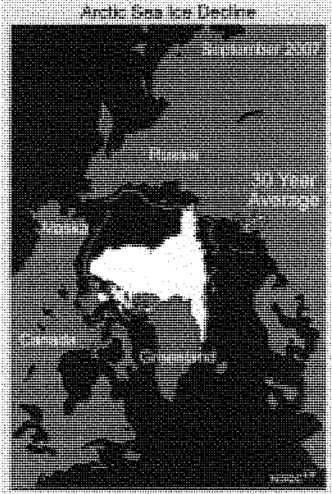
Sea ice decline
The striking thinning and downward trend in the extent of Arctic sea ice is regarded as a considerable opportunity for shippers. Continued reduction in sea ice should result in opening of additional ice-free ports, improved access to ports and natural resources in remote areas, and longer shipping seasons, but it is likely to increase erosion rates on land as well, raising costs for maintaining ports and other transportation infrastructure.[132,220]

Later this century and beyond, shippers are looking forward to new Arctic shipping routes, including the fabled Northwest Passage, which could provide significant costs savings in shipping times and distances. However, the next few decades are likely to be very unpredictable for shipping through these new routes. The past three decades have seen very high year-to-year variability of sea ice extent in the Canadian Arctic, despite the overall decrease in September sea ice extent. The loss of sea ice from the shipping channels of the Canadian Archipelago might actually allow more frequent intrusions of icebergs, which would continue to impede shipping through the Northwest Passage.

Lack of sea ice, especially on the northern shores of Alaska, creates conditions whereby storms produce waves that cause serious coastal erosion.[137,219] Already a number of small towns, roads, and airports are threatened by retreating coastlines, necessitating the planned relocation of these communities (see *Alaska* region).[132,220]

Thawing ground
The challenges warming presents for transportation on land are considerable.[164] For highways, thawing of permafrost causes settling of the roadbed and

Arctic Sea Ice Decline



The pink line shows the average September sea ice extent from 1979 through the present. The white area shows September 2007 sea ice extent. In 2008, the extent was slightly larger than 2007, but the ice was thinner, resulting in a lower total volume of sea ice. In addition, recent years have had less ice that persisted over numerous years and more first-year ice, which melts more quickly.[217]

frost heaves that adversely affect the integrity of the road structure and its load-carrying capacity. The majority of Alaska's highways are located in areas where permafrost is discontinuous, and dealing with thaw settlement problems already claims a significant portion of highway maintenance dollars.

Bridges and large culverts are particularly sensitive to movement caused by thawing permafrost and are often much more difficult than roads to repair and modify for changing site conditions. Thus, designing these facilities to take climate change into account is even more critical than is the case for roads.

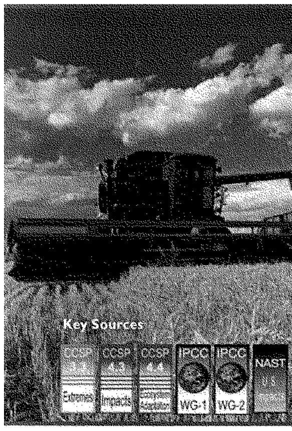
Another impact of climate change on bridges is increased scouring. Hotter, drier summers in Alaska have led to increased glacial melting and longer periods of high streamflows, causing both increased sediment in rivers and scouring of bridge supporting piers and abutments. Temporary ice roads and bridges are commonly used in many parts of Alaska to access northern communities and provide support for the mining and oil and gas industries. Rising temperatures have already shortened the season during which these critical facilities can be used. Like the highway system, the Alaska Railroad crosses permafrost terrain, and frost heave and settlement from thawing affect some portions of the track, increasing maintenance costs.[28,132,220]

A significant number of Alaska's airstrips in the southwest, northwest, and interior of the state are built on permafrost. These airstrips will require major repairs or relocation if their foundations are compromised by thawing.

The cost of maintaining Alaska's public infrastructure is projected to increase 10 to 20 percent by 2030 due to warming, costing the state an additional $4 billion to $6 billion, with roads and airports accounting for about half of this cost.[230] Private infrastructure impacts have not been evaluated.[217]

The Trans-Alaska Pipeline System, which stretches from Prudhoe Bay in the north to the ice-free port of Valdez in the south, crosses a wide range of permafrost types and varying temperature conditions. More than half of the 800-mile pipeline is elevated on vertical supports over potentially unstable permafrost. Because the system was designed in the early 1970s on the basis of permafrost and climate conditions of the 1950 to 1970 period, it requires continuous monitoring and some supports have had to be replaced.

Travel over the tundra for oil and gas exploration and extraction is limited to the period when the ground is sufficiently frozen to avoid damage to the fragile tundra. In recent decades, the number of days that exploration and extraction equipment could be used has dropped from 200 days to 100 days per year due to warming.[220] With continued warming, the number of exploration days is expected to decline even more.



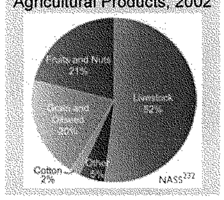
Agriculture

Key Messages:

- Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.
- Extreme events such as heavy downpours and droughts are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.
- Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.
- Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed.
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

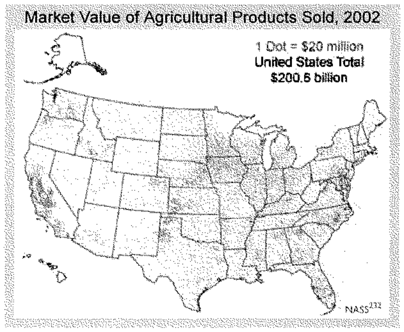
Agriculture in the United States is extremely diverse in the range of crops grown and animals raised, and produces over $200 billion a year in food commodities, with livestock accounting for more than half. Climate change will increase productivity in certain crops and regions and reduce productivity in others (see for example *Midwest* and *Great Plains* regions).[193]

Relative Contributions to Agricultural Products, 2002



While climate change clearly affects agriculture, climate is also affected by agriculture, which contributes 13.5 percent of all human-induced greenhouse gas emissions globally. In the United States, agriculture represents 8.6 percent of the nation's total greenhouse gas emissions, including 80 percent of its nitrous oxide emissions and 31 percent of its methane emissions.[231]

Market Value of Agricultural Products Sold, 2002



Increased agricultural productivity will be required in the future to supply the needs of an increasing population. Agricultural productivity is dependent upon the climate and land resources. Climate change can have both beneficial and detrimental impacts on plants. Throughout history, agricultural enterprises have coped with changes in climate through changes in management and in crop or animal selection. However, under higher heat-trapping gas emissions scenarios, the projected climate changes are likely to increasingly challenge U.S. capacity to as efficiently produce food, feed, fuel, and livestock products.

Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.

Crop responses in a changing climate reflect the interplay among three factors: rising temperatures, changing water resources, and increasing carbon dioxide concentrations. Warming generally causes plants that are below their optimum temperature to grow faster, with obvious benefits. For some plants, such as cereal crops, however, faster growth means there is less time for the grain itself to grow and mature, reducing yields.[193] For some annual crops, this can be compensated for by adjusting the planting date to avoid late season heat stress.[164]

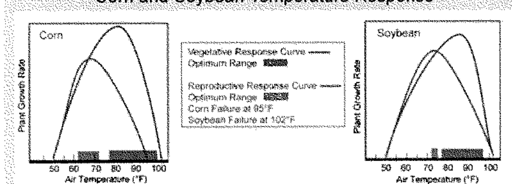
The grain-filling period (the time when the seed grows and matures) of wheat and other small grains shortens dramatically with rising temperatures. Analysis of crop responses suggests that even moderate increases in temperature will decrease yields of corn, wheat, sorghum, bean, rice, cotton, and peanut crops.[193]

Some crops are particularly sensitive to high nighttime temperatures, which have been rising even faster than daytime temperatures.[68] Nighttime temperatures are expected to continue to rise in the future. These changes in temperature are especially critical to the reproductive phase of growth because warm nights increase the respiration rate and reduce the amount of carbon that is captured during the day by photosynthesis to be retained in the fruit or grain. Further, as temperatures continue to rise and drought periods increase, crops will be more frequently exposed to temperature thresholds at which pollination and grain-set processes begin to fail and quality of vegetable crops decreases. Grain, soybean, and canola crops have relatively low optimal temperatures, and thus will have reduced yields and will increasingly begin to experience failure as warming proceeds.[193] Common snap beans show substantial yield reduction when nighttime temperatures exceed 80°F.

Higher temperatures will mean a longer growing season for crops that do well in the heat, such as melon, okra, and sweet potato, but a shorter growing season for crops more suited to cooler conditions, such as potato, lettuce, broccoli, and spinach.[193] Higher temperatures also cause plants to use more water to keep cool. This is one example of how the interplay between rising temperatures and water availability is critical to how plants respond to climate change. But fruits, vegetables, and grains can suffer even under well-watered conditions if temperatures exceed the maximum level for pollen viability in a particular plant; if temperatures exceed the threshold for that plant, it won't produce seed and so it won't reproduce.[193]

Temperature increases will cause the optimum latitude for crops to move northward; decreases in temperature would cause shifts toward the equator. Where plants can be efficiently grown depends upon climate conditions, of which temperature is one of the major factors.

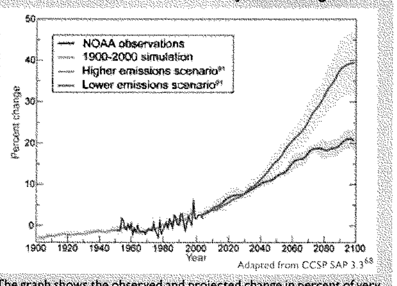
Corn and Soybean Temperature Response



For each plant variety, there is an optimal temperature for vegetative growth, with growth dropping off as temperatures increase or decrease. Similarly, there is a range of temperatures at which a plant will produce seed. Outside of this range, the plant will not reproduce. As the graphs show, corn will fail to reproduce at temperatures above 95°F and soybean above 102°F.

Plants need adequate water to maintain their temperature within an optimal range. Without water for cooling, plants will suffer heat stress. In many regions, irrigation water is used to maintain adequate temperature conditions for the growth of cool season plants (such as many vegetables), even in warm environments. With increasing demand and competition for freshwater supplies, the water needed for these crops might be increasingly limited. If water supply variability increases, it will affect plant growth and cause

Increase in Percent of Very Warm Nights



Adapted from CCSP SAP 3.3[68]

The graph shows the observed and projected change in percent of very warm nights from the 1950-1990 average in the United States. Under the lower emissions scenario,[91] the percentage of very warm nights is projected to increase about 20 percent by 2100. Under the higher emissions scenario,[91] it is projected to increase by about 40 percent.[68] The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. The projections appear smooth because they show the calculated average of many models.

reduced yields. The amount and timing of precipitation during the growing season are also critical, and will be affected by climate change. Changes in season length are also important and affect crops differently.[193]

Higher carbon dioxide levels generally cause plants to grow larger. For some crops, this is not necessarily a benefit because they are often less nutritious, with reduced nitrogen and protein content. Carbon dioxide also makes some plants more water-use efficient, meaning they produce more plant material, such as grain, on less water.[193] This is a benefit in water-limited areas and in seasons with less than normal rainfall amounts.

In some cases, adapting to climate change could be as simple as changing planting dates, which can be an effective no- or low-cost option for taking advantage of a longer growing season or avoiding crop exposure to adverse climatic conditions such as high temperature stress or low rainfall periods. Effectiveness will depend on the region, crop, and the rate and amount of warming. It is unlikely to be effective if a farmer goes to market when the supply-demand balance drives prices down. Predicting the optimum planting date for maximum profits will be more challenging in a future with increased uncertainty regarding climate effects on not only local productivity, but also on supply from competing regions.[193]

Another adaptation strategy involves changing to crop varieties with improved tolerance to heat or drought, or those that are adapted to take advantage of a longer growing season. This is less likely to be cost-effective for perennial crops, for which changing varieties is extremely expensive and new plantings take several years to reach maximum productivity. Even for annual crops, changing varieties is not always a low-cost option. Seed for new stress-tolerant varieties can be expensive, and new varieties often require investments in new planting equipment or require adjustments in a wide range of farming practices. In some cases, it is difficult to breed for genetic tolerance to elevated temperature or to identify an alternative variety that is adapted to the new climate and to local soils, practices, and market demands.

Fruits that require long winter chilling periods will experience declines. Many varieties of fruits (such as popular varieties of apples and berries) require between 400 and 1,800 cumulative hours below 45°F each winter to produce abundant yields the following summer and fall. By late this century, under higher emissions scenarios,[91] winter temperatures in many important fruit-producing regions such as the Northeast will be too consistently warm to meet these requirements. Cranberries have a particularly high chilling requirement, and there are no known low-chill varieties. Massachusetts and New Jersey supply nearly half the nation's cranberry crop. By the middle of this century, under higher emissions scenarios,[91] it is unlikely that these areas will support cranberry production due to a lack of the winter chilling they need.[233,234] Such impacts will vary by region. For example, though there will still be risks of early-season frosts and damaging winter thaws, warming is expected to improve the climate for fruit production in the Great Lakes region.[164]

A seemingly paradoxical impact of warming is that it appears to be increasing the risk of plant frost

Effects of Increased Air Pollution on Crop Yields

Ground-level ozone (a component of smog) is an air pollutant that is formed when nitrogen oxides emitted from fossil fuel burning interact with other compounds, such as unburned gasoline vapors, in the atmosphere[218] in the presence of sunlight. Higher air temperatures result in greater concentrations of ozone. Ozone levels at the land surface have risen in rural areas of the United States over the past 50 years, and they are forecast to continue increasing with warming, especially under higher emissions scenarios.[9] Plants are sensitive to ozone, and crop yields are reduced as ozone levels increase. Some crops that are particularly sensitive to ozone pollution include soybeans, wheat, oats, green beans, peppers, and some types of cotton.[191]

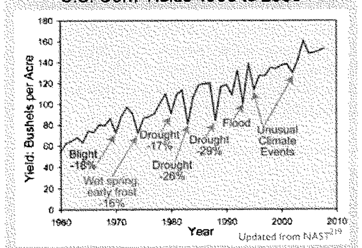
damage. Mild winters and warm, early springs, which are beginning to occur more frequently as climate warms, induce premature plant development and blooming, resulting in exposure of vulnerable young plants and plant tissues to subsequent late-season frosts. For example, the 2007 spring freeze in the eastern United States caused widespread devastation of crops and natural vegetation because the frost occurred during the flowering period of many trees and during early grain development on wheat plants.[235] Another example is occurring in the Rocky Mountains where in addition to the process described above, reduced snow cover leaves young plants unprotected from spring frosts, with some plant species already beginning to suffer as a result[236] (see *Ecosystems* sector).

Extreme events such as heavy downpours and droughts are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.

One of the most pronounced effects of climate change is the increase in heavy downpours. Precipitation has become less frequent but more intense, and this pattern is projected to continue across the United States.[112] One consequence of excessive rainfall is delayed spring planting, which jeopardizes profits for farmers paid a premium for early season production of high-value crops such as melon, sweet corn, and tomatoes. Field flooding during the growing season causes crop losses due to low oxygen levels in the soil, increased susceptibility to root diseases, and increased soil compaction due to the use of heavy farm equipment on wet soils. In spring 2008, heavy rains caused the Mississippi River to rise to about 7 feet above flood stage, inundating hundreds of thousands of acres of cropland. The flood hit just as farmers were preparing to harvest wheat and plant corn, soybeans, and cotton. Preliminary estimates of agricultural losses are around $8 billion.[233] Some farmers were put out of business and others will be recovering for years to come. The flooding caused severe erosion in some areas and also caused an increase in runoff and leaching of agricultural chemicals into surface water and groundwater.[233]

Another impact of heavy downpours is that wet conditions at harvest time result in reduced quality of many crops. Storms with heavy rainfall often are accompanied by wind gusts, and both strong winds and rain can flatten crops, causing significant damage. Vegetable and fruit crops are sensitive to even short-term, minor stresses, and as such are par-

U.S. Corn Yields 1960 to 2008



Updated from NASS[219]

While technological improvements have resulted in a general increase in corn yields, extreme weather events have caused dramatic reductions in yields in particular years. Increased variation in yield is likely to occur as temperatures increase and rainfall becomes more variable during the growing season. Without dramatic technological breakthroughs, yields are unlikely to continue their historical upward trend as temperatures rise above the optimum level for vegetative and reproductive growth.

ticularly vulnerable to weather extremes.[193] More rainfall concentrated into heavy downpours also increases the likelihood of water deficiencies at other times because of reductions in rainfall frequency.

Drought frequency and severity are projected to increase in the future over much of the United States, particularly under higher emissions scenarios.[90,91] Increased drought will be occurring at a time when crop water requirements also are increasing due to rising temperatures. Water deficits are detrimental for all crops.[233]

Temperature extremes will also pose problems. Even crop species that are well-adapted to warmth, such as tomatoes, can have reduced yield and/or quality when daytime maximum temperatures exceed 90°F for even short periods during critical reproductive stages (see maps page 34).[112] For many high-value crops, just hours or days of moderate heat stress at critical growth stages can reduce grower profits by negatively affecting visual or flavor quality, even when total yield is not reduced.[238]

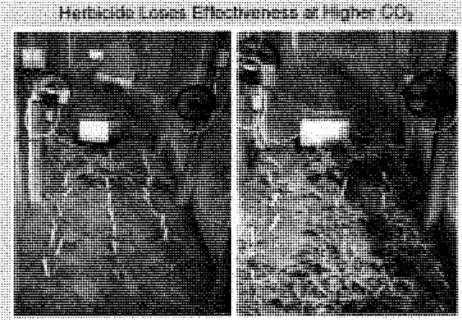
Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.

Weeds benefit more than cash crops from higher temperatures and carbon dioxide levels.[193] One concern with continued warming is the northward expansion of invasive weeds. Southern farmers currently lose more of their crops to weeds than do northern farmers. For example, southern farmers lose 64 percent of the soybean crop to weeds, while northern farmers lose 22 percent.[239] Some extremely aggressive weeds plaguing the South (such as kudzu) have historically been confined to areas where winter temperatures do not drop below specific thresholds. As temperatures continue to rise, these weeds will expand their ranges northward into important agricultural areas.[240] Kudzu currently has invaded 2.5 million acres of the Southeast and is a carrier of the fungal disease soybean rust, which represents a major and expanding threat to U.S. soybean production.[234]

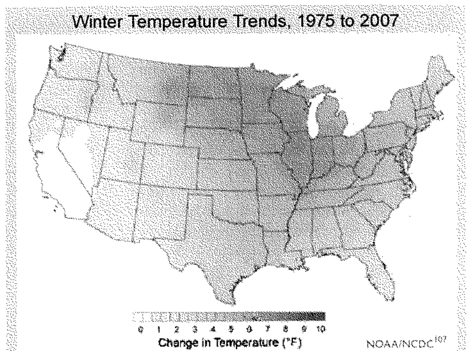
Controlling weeds currently costs the United States more than $11 billion a year, with the majority spent on herbicides;[241] so both herbicide use and costs are likely to increase as temperatures and carbon dioxide levels rise. At the same time, the most widely used herbicide in the United States, glyphosate (RoundUp®), loses its efficacy on weeds grown at carbon dioxide levels that are projected to occur in the coming decades (see photos below). Higher concentrations of the chemical and more frequent spraying thus will be needed, increasing economic and environmental costs associated with chemical use.[233]

Many insect pests and crop diseases thrive due to warming, increasing losses and necessitating greater pesticide use. Warming aids insects and diseases in several ways. Rising temperatures allow both insects and pathogens to expand their ranges northward. In addition, rapidly rising winter temperatures allow more insects to survive over the winter, whereas cold winters once controlled their populations. Some of these insects, in addition to directly

Herbicide Loses Effectiveness at Higher CO_2



damaging crops, also carry diseases that harm crops. Crop diseases in general are likely to increase as earlier springs and warmer winters allow proliferation and higher survival rates of disease pathogens and parasites.[193,234] The longer growing season will allow some insects to produce more generations in a single season, greatly increasing their populations. Finally, plants grown in higher carbon dioxide conditions tend to be less nutritious, so insects must eat more to meet their protein requirements, causing greater destruction to crops.[193]



Temperatures are rising faster in winter than in any other season, especially in many key agricultural regions. This allows many insect pests and crop diseases to expand and thrive, creating increasing challenges for agriculture. As indicated by the map, the Midwest and northern Great Plains have experienced increases of more than 7°F in average winter temperatures over the past 30 years.

Due to the increased presence of pests, spraying is already much more common in warmer areas than in cooler areas. For example, Florida sweet corn growers spray their fields 15 to 32 times a year to fight pests such as corn borer and corn earworm, while New York farmers average zero to five times.[193] In addition, higher temperatures are known to reduce the effectiveness of certain classes of pesticides (pyrethroids and spinosad).

A particularly unpleasant example of how carbon dioxide tends to favor undesirable plants is found in the response of poison ivy to rising carbon dioxide concentrations. Poison ivy thrives in air with extra carbon dioxide in it, growing bigger and producing a more toxic form of the oil, urushiol, which causes painful skin reactions in 80 percent of people. Contact with poison ivy is one of the most widely reported ailments at poison centers in the United States, causing more than 350,000 cases of contact dermatitis each year. The growth stimulation of poison ivy due to increasing carbon dioxide concentration exceeds that of most other woody species. Given continued increases in carbon dioxide emissions, poison ivy is expected to become more abundant and more toxic in the future, with implications for forests and human health.[234]

Higher temperatures, longer growing seasons, and increased drought will lead to increased agricultural water use in some areas. Obtaining the maximum "carbon dioxide fertilization" benefit often requires more efficient use of water and fertilizers that better synchronize plant demand with supply. Farmers are likely to respond to more aggressive and invasive weeds, insects, and pathogens with increased use of herbicides, insecticides, and fungicides. Where increases in water and chemical inputs become necessary, this will increase costs for the farmer, as well as having society-wide impacts by depleting water supply, increasing reactive nitrogen and pesticide loads to the environment, and increasing risks to food safety and human exposure to pesticides.

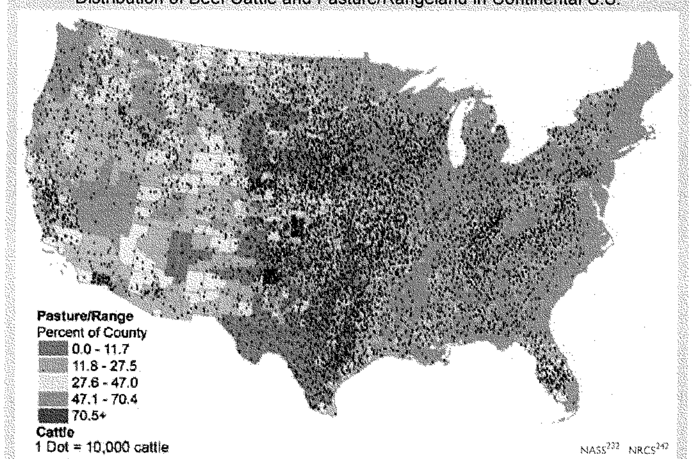
Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed.

Beef cattle production takes place in every state in the United States, with the greatest number raised in regions that have an abundance of native or planted pastures for grazing. Generally, eastern pasturelands are planted and managed, whereas western rangelands are native pastures, which are not seeded and receive much less rainfall. There are transformations now underway in many semi-arid rangelands as a result of increasing atmospheric carbon dioxide concentration and the associated climate change. These transformations include which species of grasses dominate, as well as the forage quality of the dominant grasses. Increases in carbon dioxide are generally reducing the quality of the forage, so that more acreage is needed to provide animals with the same nutritional value, resulting in an overall decline in livestock productivity. In addition, woody shrubs and invasive cheatgrass are encroaching into grasslands, further reducing their forage value.[193] The combination of these factors leads to an overall decline in livestock productivity.

While rising atmospheric carbon dioxide concentration increases forage quantity, it has negative impacts on forage quality because plant nitrogen and protein concentrations often decline with higher concentrations of carbon dioxide.[193] This reduction in protein reduces forage quality and counters the positive effects of carbon dioxide enrichment on carbohydrates. Rising carbon dioxide concentration also has the potential to reduce the digestibility of forages that are already of poor quality. Reductions in forage quality could have pronounced detrimental effects on animal growth, reproduction, and survival, and could render livestock production unsustainable unless animal diets are supplemented with protein, adding more costs to production. On shortgrass prairie, for example, a carbon dioxide enrichment experiment reduced the protein concentration of autumn forage below critical maintenance levels for livestock in 3 out of 4 years and reduced the digestibility of forage by 14 percent in mid-summer and by 10 percent in autumn. Significantly, the grass type that thrived the most under excess carbon dioxide conditions also had the lowest protein concentration.[193]

At the scale of a region, the composition of forage plant species is determined mostly by climate and soils. The primary factor controlling the distribution and abundance of plants is water: both the

Distribution of Beef Cattle and Pasture/Rangeland in Continental U.S.



The colors show the percent of the county that is cattle pasture or rangeland, with red indicating the highest percentage. Each dot represents 10,000 cattle. Livestock production occurs in every state. Increasing concentration of carbon dioxide reduces the quality of forage, necessitating more acreage and resulting in a decline in livestock productivity.

amount of water plants use and water availability over time and space. The ability to anticipate vegetation changes at local scales and over shorter periods is limited because at these scales the response of vegetation to global-scale changes depends on a variety of local processes including the rate of disturbances such as fire and grazing, and the rate at which plant species can move across sometimes-fragmented landscapes. Nevertheless, some general patterns of vegetation change are beginning to emerge. For example, experiments indicate that a higher carbon dioxide concentration favors weeds and invasive plants over native species because invasives have traits (such as rapid growth rate and prolific seed production) that allow a larger growth response to carbon dioxide. In addition, the effect of a higher carbon dioxide concentration on plant species composition appears to be greatest where the land has been disturbed (such as by fire or grazing) and nutrient and light availability are high.[193]

Increases in temperature lengthen the growing season, and thus are likely to extend forage production into the late fall and early spring. However, overall productivity remains dependent on precipitation during the growing season.[193]

Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

Like human beings, cows, pigs, and poultry are warm-blooded animals that are sensitive to heat. In terms of production efficiency, studies show that the negative effects of hotter summers will outweigh the positive effects of warmer winters. The more the U.S. climate warms, the more production will fall. For example, an analysis projected that a warming in the range of 9 to 11°F (as in the higher emissions scenarios[91]) would cause a 10 percent decline in livestock yields in cow/calf and dairy operations in Appalachia, the Southeast (including the Mississippi Delta), and southern Plains regions, while a warming of 2.7°F would cause less than a 1 percent decline.

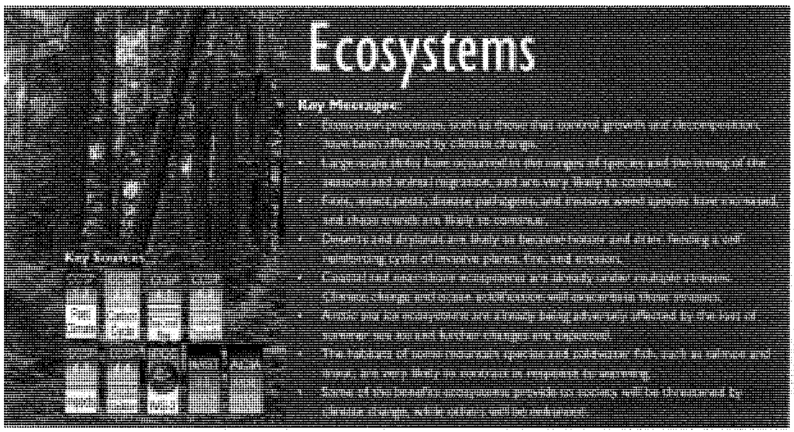
Temperature and humidity interact to cause stress in animals, just as in humans; the higher the heat and humidity, the greater the stress and discomfort, and the larger the reduction in the animals' ability to produce milk, gain weight, and reproduce. Milk production declines in dairy operations, the number of days it takes for cows to reach their target weight grows longer in meat operations, conception rate in cattle falls, and swine growth rates decline due to heat. As a result, swine, beef, and milk production are all projected to decline in a warmer world.[193]

The projected increases in air temperatures will negatively affect confined animal operations (dairy, beef, and swine) located in the central United States, increasing production costs as a result of reductions in performance associated with lower feed intake and increased requirements for energy to maintain healthy livestock. These costs do not account for the increased death of livestock associated with extreme weather events such as heat waves. Nighttime recovery is an essential element of survival when livestock are stressed by extreme heat. A feature of recent heat waves is the lack of nighttime relief. Large numbers of deaths have occurred in recent heat waves, with individual states reporting losses of 5,000 head of cattle in a single heat wave in one summer.[193]

Warming also affects parasites and disease pathogens. The earlier arrival of spring and warmer winters allow greater proliferation and survival of parasites and disease pathogens.[193] In addition, changes in rainfall distributions are likely to lead to changes in diseases sensitive to moisture. Heat stress reduces animals' ability to cope with other stresses, such as diseases and parasites. Furthermore, changes in rainfall distributions could lead to changes in diseases sensitive to relative humidity.

Maintaining livestock production would require modifying facilities to reduce heat stress on animals, using the best understanding of the chronic and acute stresses that livestock will encounter to determine the optimal modification strategy.[193]

Changing livestock species as an adaptation strategy is a much more extreme, high-risk, and, in most cases, high-cost option than changing crop varieties. Accurate predictions of climate trends and development of the infrastructure and market for the new livestock products are essential to making this an effective response.



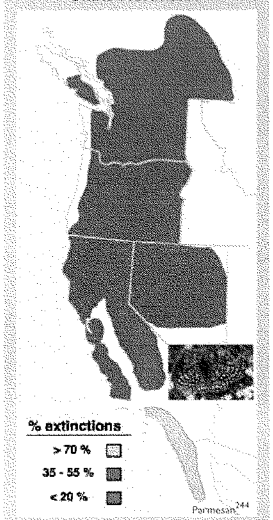
The natural functioning of the environment provides both goods – such as food and other products that are bought and sold – and services, which our society depends upon. For example, ecosystems store large amounts of carbon in plants and soils; they regulate water flow and water quality; and they stabilize local climates. These services are not assigned a financial value, but society nonetheless depends on them. Ecosystem processes are the underpinning of these services: photosynthesis, the process by which plants capture carbon dioxide from the atmosphere and create new growth; the plant and soil processes that recycle nutrients from decomposing matter and maintain soil fertility; and the processes by which plants draw water from soils and return water to the atmosphere. These ecosystem processes are affected by climate and by the concentration of carbon dioxide in the atmosphere.[70]

The diversity of living things (biodiversity) in ecosystems is itself an important resource that maintains the ability of these systems to provide the services upon which society depends. Many factors affect biodiversity including: climatic conditions; the influences of competitors, predators, parasites, and diseases; disturbances such as fire; and other physical factors. Human-induced climate change, in conjunction with other stresses, is exerting major influences on natural environments and biodiversity, and these influences are generally expected to grow with increased warming.[70]

Ecosystem processes, such as those that control growth and decomposition, have been affected by climate change.

Climate has a strong influence on the processes that control growth and development in ecosystems. Temperature increases generally speed up plant growth, rates of decomposition, and how rapidly the cycling of nutrients occurs, though other factors, such as whether sufficient water is available, also influence these rates. The growing season is lengthening as higher temperatures occur earlier in the spring. Forest growth has risen over the past several decades as a consequence of a number of factors – young forests reaching maturity, an increased concentration of carbon dioxide in the atmosphere, a longer growing season, and increased deposition of nitrogen from the atmosphere. Based on the current understanding of these processes, the individual effects are difficult to disentangle.[243]

Butterfly Range Shifts Northward



As climate warms, many species in the United States are shifting their ranges northward and to higher elevations. The map shows the response of Edith's checkerspot butterfly populations to a warming climate over the past 136 years in the American West. Over 70 percent of the southernmost populations (shown in yellow) have gone extinct. The northernmost populations and those above 8,000 feet elevation in the cooler climate of California's Sierra Nevada (shown in green) are still thriving. These differences in numbers of population extinctions across the geographic range of the butterfly have resulted in the average location shifting northward and to higher elevations over the past century, illustrating how climate change is altering the ranges of many species. Because their change in range is slow, most species are not expected to be able to keep up with the rapid climate change projected in the coming decades.[244]

A higher atmospheric carbon dioxide concentration causes trees and other plants to capture more carbon from the atmosphere, but experiments show that trees put much of this extra carbon into producing fine roots and twigs, rather than new wood. The effect of carbon dioxide in increasing growth thus seems to be relatively modest, and generally is seen most strongly in young forests on fertile soils where there is also sufficient water to sustain this growth. In the future, as atmospheric carbon dioxide continues to rise, and as climate continues to change, forest growth in some regions is projected to increase, especially in relatively young forests on fertile soils.[243]

Forest productivity is thus projected to increase in much of the East, while it is projected to decrease in much of the West where water is scarce and projected to become more so. Wherever droughts increase, forest productivity will decrease and tree death will increase. In addition to occurring in much of the West, these conditions are projected to occur in parts of Alaska and in the eastern part of the Southeast.[243]

Large-scale shifts have occurred in the ranges of species and the timing of the seasons and animal migration, and are very likely to continue.

Climate change is already having impacts on animal and plant species throughout the United States. Some of the most obvious changes are related to the timing of the seasons: when plants bud in spring, when birds and other animals migrate, and so on. In the United States, spring now arrives an average of 10 days to two weeks earlier than it did 20 years ago. The growing season is lengthening over much of the continental United States. Many migratory bird species are arriving earlier. For example, a study of northeastern birds that migrate long distances found that birds wintering in the southern United States now arrive back in the Northeast an average of 13 days earlier than they did during the first half of the last century. Birds wintering in South America arrive back in the Northeast an average of four days earlier.[70]

Another major change is in the geographic distribution of species. The ranges of many species in the United States have shifted northward and upward in elevation. For example, the ranges of many butterfly species have expanded northward, contracted at the southern edge, and shifted to higher elevations as warming has continued. A study of Edith's checkerspot butterfly showed that 40 percent of the populations below 2,400 feet have gone extinct, despite the availability of otherwise suitable habitat and food supply. The checkerspot's most southern populations also have gone extinct, while new populations have been established north of the previous northern boundary for the species.[70]

For butterflies, birds, and other species, one of the concerns with such changes in geographic range and timing of migration is the potential for mismatches between species and the resources they need to survive. The rapidly changing landscape, such as new highways and expanding urban areas, can create barriers that limit habitat and increase species loss. Failure of synchronicity between butterflies and the resources they depend upon has led to local population extinctions of the checkerspot butterfly during extreme drought and low-snowpack years in California.[70]

Tree species shifts

Forest tree species also are expected to shift their ranges northward and upslope in response to climate change, although specific quantitative predictions are very difficult to make because of the complexity of human land use and many other factors. This would result in major changes in the character of U.S. forests and the types of forests that will be most prevalent in different regions. In the United States, some common forests types are projected to expand, such as oak-hickory; others are projected to contract, such as maple-beech-birch. Still others, such as spruce-fir, are likely to disappear from the United States altogether.[243]

In Alaska, vegetation changes are already underway due to warming. Tree line is shifting northward into tundra, encroaching on the habitat for many migratory birds and land animals such as caribou that depend on the open tundra landscape.[245]

Marine species shifts and effects on fisheries

The distribution of marine fish and plankton are predominantly determined by climate, so it is not surprising that marine species in U.S. waters are moving northward and that the timing of plankton blooms is shifting. Extensive shifts in the ranges and distributions of both warmwater and coldwater species of fish have been documented.[70] For example, in the waters around Alaska, climate change already is causing significant alterations in marine ecosystems with important implications for fisheries and the people who depend on them (see *Alaska* region).

In the Pacific, climate change is expected to cause an eastward shift in the location of tuna stocks.[246] It is clear that such shifts are related to climate, including natural modes of climate variability such as the cycles of El Niño and La Niña. However, it is unclear how these modes of ocean variability will change as global climate continues to change, and therefore it is very difficult to predict quantitatively how marine fish and plankton species' distributions might shift as a function of climate change.[70]

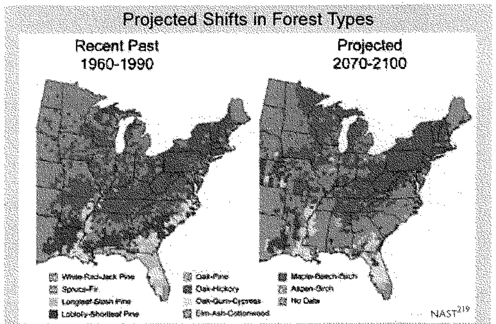
Breaking up of existing ecosystems

As warming drives changes in timing and geographic ranges for various species, it is important to note that entire communities of species do not shift intact. Rather, the range and timing of each species shifts in response to its sensitivity to climate change, its mobility, its lifespan, and the availability of the resources it needs (such as soil, moisture, food, and shelter). The speed with which species can shift their ranges is influenced by factors including their size, lifespan, and seed dispersal techniques in plants. In addition, migratory pathways must be available, such as northward flowing rivers which serve as conduits for fish. Some migratory pathways may be blocked by development and habitat fragmentation. All of these variations result in the breakup of existing ecosystems and formation of new ones, with unknown consequences.[220]

Extinctions and climate change

Interactions among impacts of climate change and other stressors can increase the risk of species extinction. Extinction rates of plants and animals have already risen considerably, with the vast majority of these extinctions attributed to loss of habitat or over-exploitation.[247] Climate change has been identified as a serious risk factor for the fu-

Projected Shifts in Forest Types



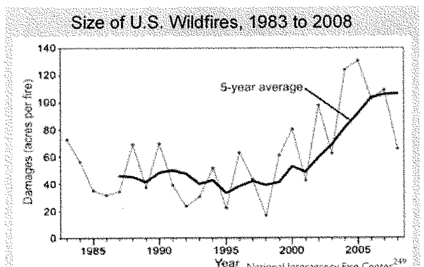
The maps show current and projected forest types. Major changes are projected for many regions. For example, in the Northeast, under a mid-range warming scenario, the currently dominant maple-beech-birch forest type is projected to be completely displaced by other forest types in a warmer future.[243]

ture, however, since it is one of the environmental stresses on species and ecosystems that is continuing to increase.[247] The Intergovernmental Panel on Climate Change has estimated that if a warming of 3.5 to 5.5°F occurs, 20 to 30 percent of species that have been studied would be in climate zones that are far outside of their current ranges, and would therefore likely be at risk of extinction.[248] One reason this percentage is so high is that climate change would be superimposed on other stresses including habitat loss and continued overharvesting of some species, resulting in considerable stress on populations and species.

Fires, insect pests, disease pathogens, and invasive weed species have increased, and these trends are likely to continue.

Forest fires

In the western United States, both the frequency of large wildfires and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures.[294] These changes in climate have reduced the availability of moisture, drying out the vegetation that provides the fuel for fires. Alaska also has experienced large increases in fire, with the area burned more than doubling in recent decades. As in the western United States, higher air temperature is a key factor. In Alaska, for example, June air temperatures alone explained approximately 38 percent of the increase in the area burned annually from 1950 to 2003.[243]



Data on wildland fires in the United States show that the number of acres burned per fire has increased since the 1980s.

Insect pests

Insect pests are economically important stresses on forest ecosystems in the United States. Coupled with pathogens, they cost $1.5 billion in damage per year. Forest insect pests are sensitive to climatic variations in many stages of their lives. Changes in climate have contributed significantly to several major insect pest outbreaks in the United States and Canada over the past several decades. The mountain pine beetle has infested lodgepole pine in British Columbia. Over 33 million acres of forest have been affected, by far the largest such outbreak in recorded history. Another 1.5 million acres have been infested by pine beetle in Colorado. Spruce beetle has affected more than 2.5 million acres in Alaska (see *Alaska* region) and western Canada. The combination of drought and high temperatures also has led to serious insect infestations and death of piñon pine in the Southwest, and to various insect pest attacks throughout the forests of the eastern United States.[243]

Rising temperatures increase insect outbreaks in a number of ways. First, winter temperatures above a certain threshold allow more insects to survive the cold season that normally limits their numbers. Second, the longer warm season allows them to develop faster, sometimes completing two life cycles instead of one in a single growing season. Third, warmer conditions help expand their ranges northward. And fourth, drought stress reduces trees' ability to resist insect attack (for example, by pushing back against boring insects with the pressure of their sap). Spruce beetle, pine beetle, spruce budworm, and woolly adelgid (which attacks eastern hemlocks) are just some of the insects that are proliferating in the United States, devastating many forests. These outbreaks are projected to increase with ongoing warming. Trees killed by insects also provide more dry fuel for wildfires.[70,243,250]

Disease pathogens and their carriers

One consequence of a longer, warmer growing season and less extreme cold in winter is that opportunities are created for many insect pests and disease pathogens to flourish. Accumulating evidence links the spread of disease pathogens to a warming climate. For example, a recent study showed that widespread amphibian extinctions in the mountains of Costa Rica are linked to changes in climatic conditions which are thought to have enabled the proliferation of an amphibian disease.[70,251]

Diseases that affect wildlife and the living things that carry these diseases have been expanding their geographic ranges as climate heats up. Depending on their specific adaptations to current climate, many parasites, and the insects, spiders, and scorpions that carry and transmit diseases, die or fail to develop below threshold temperatures. Therefore, as temperatures rise, more of these disease-carrying creatures survive. For some species, rates of reproduction, population growth, and biting, tend to increase with increasing temperatures, up to a limit. Some parasites' development rates and infectivity periods also increase with temperature.[70] An analysis of diseases among marine species found that diseases were increasing for mammals, corals, turtles, and mollusks, while no trends were detected for sharks, rays, crabs, and shrimp.[70]

Invasive plants

Problems involving invasive plant species arise from a mix of human-induced changes, including disturbance of the land surface (such as through over grazing or clearing natural vegetation for development), deliberate or accidental transport of non-native species, the increase in available nitrogen through over-fertilization of crops, and the rising carbon dioxide concentration and the resulting climate change.[243] Human-induced climate change is not generally the initiating factor, nor the most important one, but it is becoming a more important part of the mix.

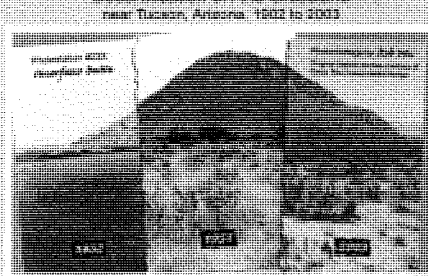
The increasing carbon dioxide concentration stimulates the growth of most plant species, and some invasive plants respond with greater growth rates than native plants. Beyond this, invasive plants appear to better tolerate a wider range of environmental conditions and may be more successful in a warming world because they can migrate and establish themselves in new sites more rapidly than native plants.[70] They are also not usually dependent on external pollinators or seed dispersers to reproduce. For all of these reasons, invasive plant species present a growing problem that is extremely difficult to control once unleashed.[70]

Deserts and drylands are likely to become hotter and drier, feeding a self-reinforcing cycle of invasive plants, fire, and erosion.

The arid Southwest is projected to become even drier in this century. There is emerging evidence that this is already underway.[34] Deserts in the United States are also projected to expand to the north, east, and upward in elevation in response to projected warming and associated changes in climate.

Increased drying in the region contributes to a variety of changes that exacerbate a cycle of desertification. Increased drought conditions cause perennial plants to die due to water stress and increased susceptibility to plant diseases. At the same time, non-native grasses have invaded the region. As these grasses increase in abundance, they provide more fuel for fires, causing fire frequency to increase in a self-reinforcing cycle that leads to further losses of vegetation. When it does rain, the rain tends to come in heavy downpours, and since there is less vegetation to protect the soil, water erosion increases. Higher air temperatures and decreased soil moisture reduce soil stability, further exacerbating erosion. And with a growing population needing water for urban uses, hydroelectric generation, and agriculture, there is increasing pressure on mountain water sources that would otherwise flow to desert river areas.[70,149]

Desertification of Arid Grassland
near Tucson, Arizona, 1902 to 2003



The photo series shows the progression from arid grassland to desert (desertification) over a 100-year period. The change is the result of grazing management and reduced rainfall in the Southwest.

The response of arid lands to climate change also depends on how other factors interact with climate at local scales. Large-scale, unregulated livestock grazing in the Southwest during the late 1800s and early 1900s is widely regarded as having contributed to widespread desertification. Grazing peaked around 1920 on public lands in the West. By the 1970s, grazing had been reduced by about 70 percent, but the arid lands have been very slow to recover from its impacts. Warmer and drier climate conditions are expected to slow recovery even more. In addition, the land resource in the Southwest is currently managed more for providing water for people than for protecting the productivity of the landscape. As a result, the land resource is likely to be further degraded and its recovery hampered.[243]

Coastal and near-shore ecosystems are already under multiple stresses. Climate change and ocean acidification will exacerbate these stresses.

Coastal and near-shore marine ecosystems are vulnerable to a host of climate change-related effects including increasing air and water temperatures, ocean acidification, changes in runoff from the land, sea-level rise, and altered currents. Some of these changes have already led to coral bleaching, shifts in species ranges, increased storm intensity in some regions, dramatic reductions in sea ice extent and thickness along the Alaskan coast,[137] and other significant changes to the nation's coastlines and marine ecosystems.[70]

The interface between land and sea is important, as many species, including many endangered species, depend on it at some point in their life cycle. In addition, coastal areas buffer inland areas from the effects of wave action and storms.[247] Coastal wetlands, intertidal areas, and other near-shore ecosystems are subject to a variety of environmental stresses.[254,255] Sea-level rise, increased coastal storm intensity, and rising temperatures contribute to increased vulnerability of coastal wetland ecosystems. It has been estimated that 3 feet of sea-level rise (within the range of projections for this century) would inundate about 65 percent of the coastal marshlands and swamps in the contiguous United States.[256] The combination of sea-level rise, local land sinking, and related factors already have resulted in substantially higher relative sea-level rise along the Gulf of Mexico and the mid-Atlantic coast, more so than on the Pacific Coast.[43,254] In Louisiana alone, over one-third of the coastal plain that existed a century ago has since been lost,[254] which is mostly due to local land sinking.[70] Barrier islands are also losing land at an increasing rate[257] (see *Southeast* region), and they are particularly important in protecting the coastline in some regions vulnerable to sea-level rise and storm surge.

Coral reefs

Coral reefs are very diverse ecosystems that support many other species by providing food and habitat. In addition to their ecological value, coral reefs provide billions of dollars in services including tourism, fish breeding habitat, and protection of coastlines. Corals face a host of challenges associated with human activities such as poorly regulated tourism, destructive fishing, and pollution, in addition to climate change-related stresses.[70]

Corals are marine animals that host symbiotic algae which help nourish the animals and give the corals their color. When corals are stressed by increases in water temperatures or ultraviolet light, they lose their algae and turn white, a process called coral bleaching. If the stress persists, the corals die. Intensities and frequencies of bleaching events, clearly driven by warming in surface water, have increased substantially over the past 30 years, leading to the death or severe damage of about one-third of the world's corals.[70]

The United States has extensive coral reef ecosystems in the Caribbean, Atlantic, and Pacific oceans. In 2005, the Caribbean basin experienced unprecedented water temperatures that resulted in dramatic coral bleaching with some sites in the U.S. Virgin Islands seeing 90 percent of the coral bleached. Some corals began to recover when water temperatures decreased, but later that year disease appeared, striking the previously bleached and weakened coral. To date, 50 percent of the corals in Virgin Islands National Park have died from the bleaching and disease events. In the Florida Keys, summer bleaching in 2005 was also followed by disease in September.[70]

But rising temperature is not the only stress coral reefs face. As the carbon dioxide concentration in the air increases, more carbon dioxide is absorbed into the world's oceans, leading to their acidification. This makes less calcium carbonate available for corals and other sea life to build their skeletons and shells.[258] If carbon dioxide concentrations continue to rise and the resulting acidification proceeds, eventually, corals and other ocean life that rely on calcium carbonate will not be able to build these skeletons and shells at all. The implications of such extreme changes in ocean ecosystems are not clear, but there is now evidence that in some ocean areas, such as along the Northwest coast, acidification is already occurring[70,259] (see *Coasts* region for more discussion of ocean acidification).

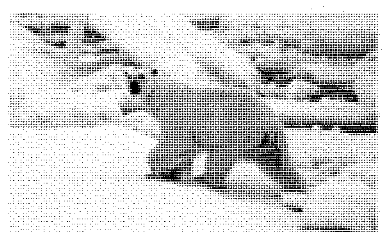
Arctic sea ice ecosystems are already being adversely affected by the loss of summer sea ice and further changes are expected.

Perhaps most vulnerable of all to the impacts of warming are Arctic ecosystems that rely on sea ice, which is vanishing rapidly and is projected to disappear entirely in summertime within this century. Algae that bloom on the underside of the sea ice form the base of a food web linking microscopic animals and fish to seals, whales, polar bears, and people. As the sea ice disappears, so too do these algae. The ice also provides a vital platform for ice-dependent seals (such as the ringed seal) to give birth, nurse their pups, and rest. Polar bears use the ice as a platform from which to hunt their prey. The walrus rests on the ice near the continental shelf between its dives to eat clams and other shellfish. As the ice edge retreats away from the shelves to deeper areas, there will be no clams nearby.[70,132,220]

The Bering Sea, off the west coast of Alaska, produces our nation's largest commercial fish harvests as well as providing food for many Native Alaskan peoples. Ultimately, the fish populations (and animals including seabirds, seals, walruses, and whales) depend on plankton blooms regulated by the extent and location of the ice edge in spring. As the sea ice continues to decline, the location, timing, and species composition of the blooms is changing. The spring melt of sea ice in the Bering Sea has long provided material that feeds the clams, shrimp, and other life forms on the ocean floor that, in turn, provide food for the walruses, gray whales, bearded seals, eider ducks, and many fish. The earlier ice melt resulting from warming, however, leads to later phytoplankton blooms that are largely consumed by microscopic animals near the sea surface, vastly decreasing the amount of food reaching the living things on the ocean floor. This will radically change the species composition of the fish and other creatures, with significant repercussions for both subsistence and commercial fishing.[70]

Ringed seals give birth in snow caves on the sea ice, which protect their pups from extreme cold and predators. Warming leads to earlier snow melt, which causes the snow caves to collapse before the pups are weaned. The small, exposed pups may die of hypothermia or be vulnerable to predation by arctic foxes, polar bears, gulls, and ravens. Gulls and ravens are arriving in the Arctic earlier as springs become warmer, increasing the birds' opportunity to prey on the seal pups.[70]

Polar bears are the top predators of the sea ice ecosystem. Because they prey primarily on ice-associated seals, they are especially vulnerable to the disappearance of sea ice. The bears' ability to catch seals depends on the presence of sea ice. In that habitat, polar bears take advantage of the fact that seals must surface to breathe in limited openings in the ice cover. In the open ocean, bears lack a hunting platform, seals are not restricted in where they can surface, and successful hunting is very rare. On shore, polar bears feed little, if at all.

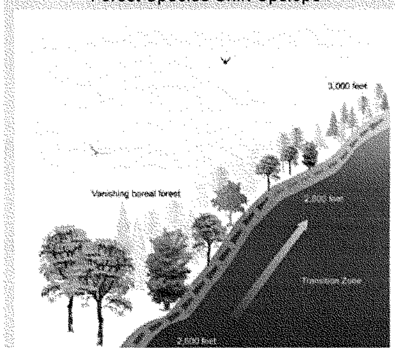

About two-thirds of the world's polar bears are projected to be gone by the middle of this century. It is projected that there will be no wild polar bears in Alaska in 75 years.[70]

In addition, the rapid rate of warming in Alaska and the rest of the Arctic in recent decades is sharply reducing the snow cover in which polar bears build dens and the sea ice they use as foraging habitat. Female polar bears build snow dens in which they hibernate for four to five months each year and in which they give birth to their cubs. Born weighing only about 1 pound, the tiny cubs depend on the snow den for warmth.

About two-thirds of the world's polar bears are projected to be gone by the middle of this century. It is projected that there will be no wild polar bears left in Alaska in 75 years.[70]

Continued warming will inevitably entail major changes in the sea ice ecosystem, to the point that its viability is in jeopardy. Some species will become extinct, while others might adapt to new habitats. The chances of species surviving the current changes may depend critically on the rate of change. The current rates of change in the sea ice ecosystem are very rapid relative to the life spans of animals including seals, walruses, and polar bears, and as such, are a major threat to their survival.[70]

Forest Species Shift Upslope



Beckage et al.[260]/Adapted from Boston Globe/Landov

As climate warms, hardwood trees out-compete evergreen trees that are adapted to colder conditions.

The habitats of some mountain species and coldwater fish, such as salmon and trout, are very likely to contract in response to warming.

The pika, pictured above, is a small mammal whose habitat is limited to cold areas near the tops of mountains. As climate warms, little suitable habitat is left. Of 25 pika populations studied in the Great Basin between the Rocky Mountains and the Sierra Nevada, more than one-third have gone extinct in recent decades.[261,262]

Animal and plant species that live in the mountains are among those particularly sensitive to rapid climate change. They include animal species such as the grizzly bear, bighorn sheep, pika, mountain goat, and wolverine. Major changes have already been observed in the pika as previously reported populations have disappeared entirely as climate has warmed over recent decades.[70] One reason mountain species are so vulnerable is that their suitable habitats are being compressed as climatic zones shift upward in elevation. Some species try to shift uphill with the changing climate, but may face constraints related to food, other species present, and so on. In addition, as species move up the mountains, those near the top simply run out of habitat.[70]

Fewer wildflowers are projected to grace the slopes of the Rocky Mountains as global warming causes earlier spring snowmelt. Larkspur, aspen fleabane, and aspen sunflower grow at an altitude of about 9,500 feet where the winter snows are deep. Once the snow melts, the flowers form buds and prepare to bloom. But warmer springs mean that the snow melts earlier, leaving the buds exposed to frost. (The percentage of buds that were frosted has doubled over the past decade.) Frost does not kill the plants, but it does make them unable to seed and reproduce, meaning there will be no next generation. Insects and other animal species depend on the flowers for food, and other species depend on those species, so the loss is likely to propagate through the food chain.[236]

Shifts in tree species on mountains in New England, where temperatures have risen 2 to 4°F in the last 40 years, offer another example. Some mountain tree species have shifted uphill by 350 feet in the last 40 years. Tree communities were relatively unchanged at low and high elevations, but in the transition zone in between (at about 2,600 feet elevation) the changes have been dramatic. Cold-loving tree species declined from 43 to 18 percent, while warmer-loving trees increased from 57 to 82 percent. Overall, the transition zone has shifted about 350 feet uphill in just a few decades, a surprisingly rapid rate since these are trees that live for hundreds of years. One possibility is that as trees were damaged or killed by air pollution, it left an opportunity for the warming-induced transition to occur more quickly. These results indicate that the composition of high elevation forests is changing rapidly.[260]

Coldwater fish

Salmon and other coldwater fish species in the United States are at particular risk from warming. Salmon are under threat from a variety of human activities, but global warming is a growing source of stress. Rising temperatures affect salmon in several important ways. As precipitation increasingly falls as rain rather than snow, it feeds floods that wash away salmon eggs incubating in the streambed. Warmer water leads eggs to hatch earlier in the year, so the young are smaller and more vulnerable to predators. Warmer conditions increase the fish's metabolism, taking energy away from growth and forcing the fish to find more food, but earlier hatching of eggs could put them out of sync with the insects they eat. Earlier melting of snow leaves rivers and streams warmer and shallower in summer and fall. Diseases and parasites tend to flourish in warmer water. Studies suggest that up to 40 percent of Northwest salmon populations may be lost by 2050.[263]

Large declines in trout populations are also projected to occur around the United States. Over half of the wild trout populations are likely to disappear from the southern Appalachian Mountains because of the effects of rising stream temperatures. Losses of western trout populations may exceed 60 percent in certain regions. About 90 percent of bull trout, which live in western rivers in some of the country's most wild places, are projected to be lost due to warming. Pennsylvania is predicted to lose 50 percent of its trout habitat in the coming decades. Projected losses of trout habitat for some warmer states, such as North Carolina and Virginia, are up to 90 percent.[264]

Some of the benefits ecosystems provide to society will be threatened by climate change, while others will be enhanced.

Human well-being depends on the Earth's ecosystems and the services that they provide to sustain and fulfill human life.[265] These services are important to human well-being because they contribute to basic material needs, physical and psychological health, security, and economic activity. A recent assessment reported that of 24 vital ecosystem services, 15 were being degraded by human activity.[247] Climate change is one of several human-induced stresses that threaten to intensify and extend these adverse impacts to biodiversity, ecosystems, and the services they provide. Two of many possible examples follow.

Forests and carbon storage

Forests provide many services important to the well-being of Americans: air and water quality maintenance, water flow regulation, and watershed protection; wildlife habitat and biodiversity conservation; recreational opportunities and aesthetic and spiritual fulfillment; raw materials for wood and paper products; and climate regulation and carbon storage. A changing climate will alter forests and the services they provide. Most of these changes are likely to be detrimental.

In the United States, forest growth and long-lived forest products currently offset about 20 percent of U.S. fossil fuel carbon emissions.[140,257] This carbon "sink" is an enormous service provided by forests and its persistence or growth will be important to limiting the atmospheric carbon dioxide concentration. The scale of the challenge of increasing this sink is very large. To offset an additional 10 percent of U.S. emissions through tree planting would require converting one-third of current croplands to forests.[243]

Recreational opportunities

Tourism is one of the largest economic sectors in the world, and it is also one of the fastest growing;[266] the jobs created by recreational tourism provide economic benefits not only to individuals but also to communities. Slightly more than 90 percent of the U.S. population participates in some form of outdoor recreation, representing nearly 270 million participants,[267] and several billion days spent each year in a wide variety of outdoor recreation activities.

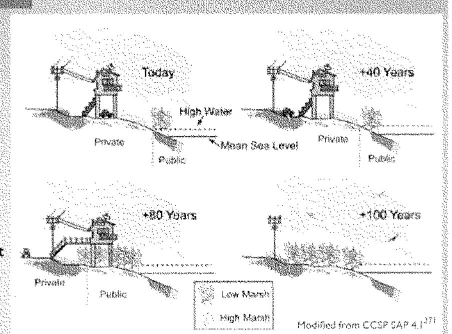
Since much recreation and tourism occurs outside, increased temperature and precipitation have a direct effect on the enjoyment of these activities, and on the desired number of visitor days and associated level of visitor spending as well as tourism employment. Weather conditions are an important factor influencing tourism visits. In addition, outdoor recreation and tourism often depends on the availability and quality of natural resources,[268] such as beaches, forests, wetlands, snow, and wildlife, all of which will be affected by climate change.

Thus, climate change can have direct effects on the natural resources that people enjoy. The length of the season for, and desirability of, several of the most popular activities – walking; visiting a beach, lakeshore, or river; sightseeing; swimming; and picnicking[267] – are likely to be enhanced by small near-term increases in temperature. Other activities are likely to be harmed by even small increases in warming, such as snow- and ice-dependent activities including skiing, snowmobiling, and ice fishing.

The net economic effect of near-term climate change on recreational activities is likely to be positive. In the longer term, however, as climate change effects on ecosystems and seasonality become more pronounced, the net economic effect on tourism and recreation is not known with certainty.[172]

Adaptation: Preserving Coastal Wetlands

Coastal wetlands are rich ecosystems that protect the shore from damage during storm surges and provide society with other services. One strategy designed to preserve coastal wetlands as sea level rises is the "rolling easement." Rolling easements allow some development near the shore, but prohibit construction of seawalls or other armoring to protect buildings; they recognize nature's right-of-way to advance inland as sea level rises. Massachusetts and Rhode Island prohibit shoreline armoring along the shores of some estuaries so that ecosystems can migrate inland, and several states limit armoring along ocean shores.[269,270]



Modified from CCSP SAP 4.1[271]

In the case shown here, the coastal marsh would reach the footprint of the house 40 years in the future. Because the house is on pilings, it could still be occupied if it is connected to a community sewage treatment system; a septic system would probably fail due to proximity to the water table. After 80 years, the marsh would have taken over the yard, and the footprint of the house would extend onto public property. The house could still be occupied but reinvestment in the property would be unlikely. After 100 years, this house would be removed, although some other houses in the area could still be occupied. Eventually, the entire area would return to nature. A home with a rolling easement would depreciate in value rather than appreciate like other coastal real estate. But if the loss were expected to occur 100 years from now, it would only reduce the current property value by 1 to 5 percent, for which the owner could be compensated.[271]

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Human Health

Climate change poses unique challenges to human health. Unlike health threats caused by a particular toxin or disease pathogen, there are many ways that climate change can lead to potentially harmful health effects. There are direct health impacts from heat waves and severe storms, ailments caused or exacerbated by air pollution and airborne allergens, and many climate-sensitive infectious diseases.[163]

Realistically assessing the potential health effects of climate change must include consideration of the capacity to manage new and changing climate conditions.[163] Whether or not increased health risks due to climate change are realized will depend largely on societal responses and underlying vulnerability. The probability of exacerbated health risks due to climate change points to a need to maintain a strong public health infrastructure to help limit future impacts.[163]

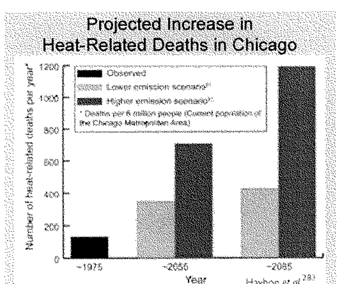
Increased risks associated with diseases originating outside the United States must also be considered because we live in an increasingly globalized world. Many poor nations are expected to suffer even greater health consequences from climate change.[272] With global trade and travel, disease flare-ups in any part of the world can potentially reach the United States. In addition, weather and climate extremes such as severe storms and drought can undermine public health infrastructure, further stress environmental resources, destabilize economies, and potentially create security risks both within the United States and internationally.[219]

The pie chart shows the distribution of deaths for 11 hazard categories as a percent of the total 19,958 deaths due to these hazards from 1970 to 2004. Heat/drought ranks highest, followed by severe weather, which includes events with multiple causes such as lightning, wind, and rain.[273] This analysis ended prior to the 2005 hurricane season which resulted in approximately 2,000 deaths.[229]

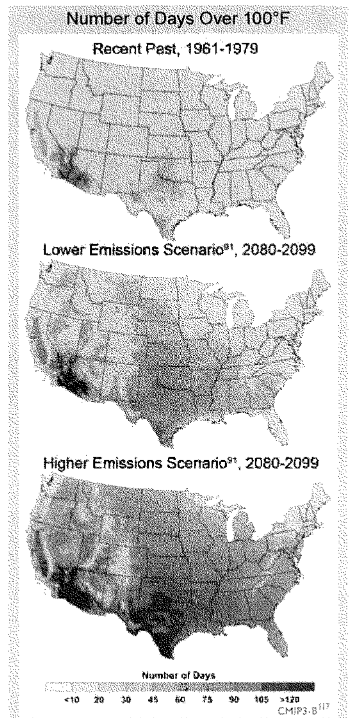
Increases in the risk of illness and death related to extreme heat and heat waves are very likely. Some reduction in the risk of death related to extreme cold is expected.

Temperatures are rising and the probability of severe heat waves is increasing. Analyses suggest that currently rare extreme heat waves will become much more common in the future (see *National Climate Change*).[68] At the same time, the U.S. population is aging, and older people are more vulnerable to hot weather and heat waves. The percentage of the U.S. population over age 65 is currently 12 percent and is projected to be 21 percent by 2050 (over 86 million people).[163,274] Diabetics are also at greater risk of heat-related death, and the prevalence of obesity and diabetes is increasing. Heat-related illnesses range from heat exhaustion to kidney stones.[275,276]

Heat is already the leading cause of weather-related deaths in the United States. More than 3,400 deaths between 1999 and 2003 were reported as resulting from exposure to excessive heat.[277] An analysis of nine U.S. cities shows that deaths due to heat increase with rising temperature and humidity.[278] From the 1970s to the 1990s, however, heat-related deaths declined.[279] This likely resulted from a rapid



Increases in heat-related deaths are projected in cities around the nation, especially under higher emissions scenarios.[91] This analysis included some, but not all possible, adaptation measures. The graph shows the projected number of deaths per year, averaged over a three-decade period around 1975, 2055, and 2085 for the City of Chicago under lower and higher emissions.[91]



The number of days in which the temperature exceeds 100°F by late this century, compared to the 1960s and 1970s, is projected to increase strongly across the United States. For example, parts of Texas that recently experienced about 10 to 20 days per year over 100°F are expected to experience more than 100 days per year in which the temperature exceeds 100°F by the end of the century under the higher emissions scenario.[91]

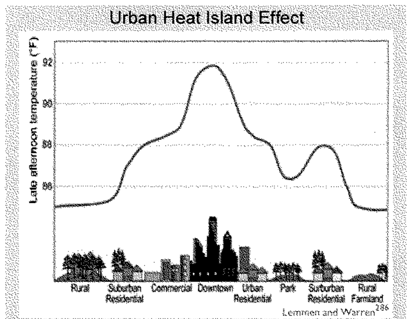
increase in the use of air conditioning. In 1978, 44 percent of households were without air conditioning, whereas in 2005, only 16 percent of the U.S. population lived without it (and only 3 percent did not have it in the South).[280,281] With air conditioning reaching near saturation, a recent study found that the general decline in heat-related deaths seems to have leveled off since the mid-1990s.[282]

As human-induced warming is projected to raise average temperatures by about 6 to 11°F in this century under a higher emissions scenario,[91] heat waves are expected to continue to increase in frequency, severity, and duration.[68,112] For example, by the end of this century, the number of heat-wave days in Los Angeles is projected to double,[284] and the number in Chicago to quadruple,[285] if emissions are not reduced.

Projections for Chicago suggest that the average number of deaths due to beat waves would more than double by 2050 under a lower emissions scenario[91] and quadruple under a high emissions scenario[91] (see figure page 90).[283]

A study of climate change impacts in California projects that, by the 2090s, annual heat-related deaths in Los Angeles would increase by two to three times under a lower emissions scenario and by five to seven times under a higher emissions scenario, compared to a 1990s baseline of about 165 deaths. These estimates assume that people will have become somewhat more accustomed to higher temperatures. Without such acclimatization, these estimates are projected to be about 20 to 25 percent higher.[284]

The full effect of global warming on heat-related illness and death involves a number of factors including actual changes in temperature (averages, highs, and lows); and human population characteristics, such as age, wealth, and fitness. In addition, adaptation at the scale of a city includes options such as heat wave early warning systems, urban design to reduce heat loads, and enhanced services during heat waves.[163]



Large amounts of concrete and asphalt in cities absorb and hold heat. Tall buildings prevent heat from dissipating and reduce air flow. At the same time, there is generally little vegetation to provide shade and evaporative cooling. As a result, parts of cities can be up to 10°F warmer than the surrounding rural areas, compounding the temperature increases that people experience as a result of human-induced warming.[313]

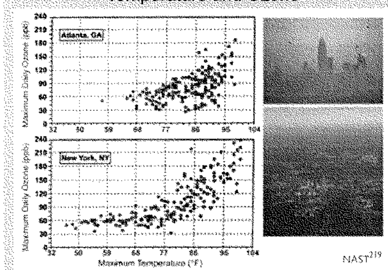
Reduced extreme cold

In a warmer world, the number of deaths caused by extremely low temperatures would be expected to drop, although in general, it is uncertain how climate change will affect net mortality.[163] Nevertheless, a recent study that analyzed daily mortality and weather data with regard to 6,513,330 deaths in 50 U.S. cities between 1989 and 2000 shows a marked difference between deaths resulting from hot and cold temperatures. The researchers found that, on average, cold snaps increased death rates

Reducing Deaths During Heat Waves

In the mid-1990s, Philadelphia became the first U.S. city to implement a system for reducing the risk of death during heat waves. The city focuses its efforts on the elderly, homeless, and poor. During a heat wave, a heat alert is issued and news organizations are provided with tips on how vulnerable people can protect themselves. The health department and thousands of block captains use a buddy system to check on elderly residents in their homes; electric utilities voluntarily refrain from shutting off services for non-payment; and public cooling places extend their hours. The city operates a "Heatline" where nurses are standing by to assist callers experiencing health problems; if callers are deemed "at risk," mobile units are dispatched to the residence. The city has also implemented a "Cool Homes Program" for elderly, low-income residents, which provides measures such as roof coatings and roof insulation that save energy and lower indoor temperatures. Philadelphia's system is estimated to have saved 117 lives over its first 3 years of operation.[illegible]

Temperature and Ozone



NAST[219]

The graphs illustrate the observed association between ground-level ozone (a component of smog) concentration in parts per billion (ppb) and temperature in Atlanta and New York City (May to October 1988 to 1990).[219] The projected higher temperatures across the United States in this century are likely to increase the occurrence of high ozone concentrations, although this will also depend on emissions of ozone precursors and meteorological factors. Ground-level ozone can exacerbate respiratory diseases and cause short-term reductions in lung function.

by 1.6 percent, while heat waves triggered a 5.7 percent increase in death rates.[289] The analysis found that the reduction in deaths as a result of relatively milder winters attributable to global warming will be substantially less than the increase in deaths due to summertime heat extremes.

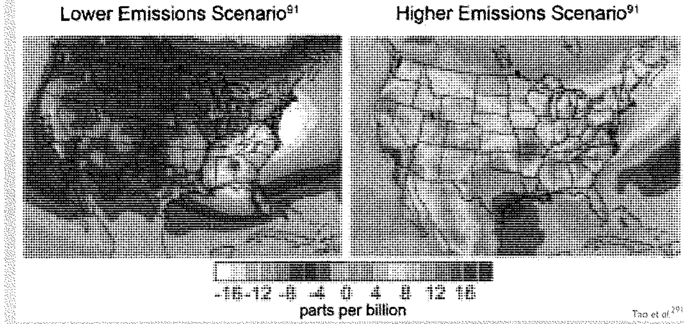
Many factors contribute to winter deaths, including highly seasonal diseases such as influenza and pneumonia. It is unclear how these diseases are affected by temperature.[163]

Warming is likely to make it more challenging to meet air quality standards necessary to protect public health.

Poor air quality, especially in cities, is a serious concern across the United States. Half of all Americans, 158 million people, live in counties where air pollution exceeds national health standards.[290] While the Clean Air Act has improved air quality, higher temperatures and associated stagnant air masses are expected to make it more challenging to meet air quality standards, particularly for ground-level ozone (a component of smog).[13] It

Projected Change in Ground-Level Ozone, 2090s

Lower Emissions Scenario[91] Higher Emissions Scenario[91]

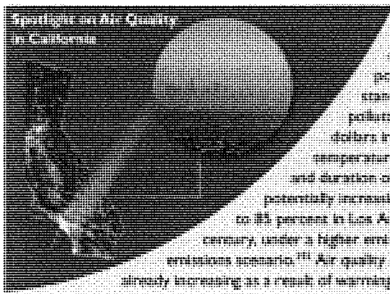


Tao et al.[291]

The maps show projected changes in ground-level ozone (a component of smog) for the 2090s, averaged over the summer months (June through August), relative to 1996-2000, under lower and higher emissions scenarios, which include both greenhouse gases and emissions that lead to ozone formation (some of which decrease under the lower emissions scenario).[91] By themselves, higher temperatures and other projected climate changes would increase ozone levels under both scenarios. However, the maps indicate that future projections of ozone depend heavily on emissions, with the higher emissions scenario[91] increasing ozone by large amounts, while the lower emissions scenario[91] results in an overall decrease in ground-level ozone by the end of the century.[291]

has been firmly established that breathing ozone results in short-term decreases in lung function and damages the cells lining the lungs. It also increases the incidence of asthma-related hospital visits and premature deaths.[272] Vulnerability to ozone effects is greater for those who spend time outdoors, especially with physical exertion, because this results in a higher cumulative dose to their lungs. As a result, children, outdoor workers, and athletes are at higher risk for these ailments.[163]

Ground-level ozone concentrations are affected by many factors including weather conditions, emissions of gases from vehicles and industry that lead



Spotlight on Air Quality in California

Californians currently experience the worst air quality in the nation. More than 90 percent of the population lives in areas that violate state air quality standards for ground-level ozone or small particles. These pollutants cause an estimated 8,800 deaths and over a billion dollars in health care costs every year in California. Higher temperatures are projected to increase the frequency, intensity, and duration of conditions conducive to air pollution formation, potentially increasing the number of days conducive to air pollution by 75 to 85 percent in Los Angeles and the San Joaquin Valley, toward the end of this century, under a higher emissions scenario, and by 25 to 35 percent under a lower emissions scenario. Air quality could be further compromised by wildfires, which are already increasing as a result of warming.

Adaptation: Improving Urban Air Quality

Because ground-level ozone is related to temperature (see figure at top of previous page), air quality is projected to become worse with human-induced climate change. Many areas in the country already have plans in place for responding to air quality problems. For example, the Air Quality Alert program in Rhode Island encourages residents to reduce air pollutant emissions by limiting car travel and the use of small engines, lawn mowers, and charcoal lighter fluids on days when ground-level ozone is high. Television weather reports include alerts when ground-level ozone is high, warning especially susceptible people to limit their time outdoors. To help cut down on the use of cars, all regular bus routes are free on Air Quality Alert days.

Pennsylvania offers the following suggestions for high ozone days:

- Refuel vehicles after dark. Avoid spilling gasoline and stop fueling when the pump shuts off automatically.
- Conserve energy. Do not overcool homes. Turn off lights and appliances that are not in use. Wash clothes and dishes only in full loads.
- Limit daytime driving. Consider carpooling or taking public transportation. Properly maintain vehicles, which also helps to save fuel.
- Limit outdoor activities, such as mowing the lawn or playing sports, to the evening hours.
- Avoid burning leaves, trash, and other materials.

Traffic restrictions imposed during the 1996 summer Olympics in Atlanta quantified the direct respiratory health benefits of reducing the number of cars and the amount of their tailpipe emissions from an urban environment. Peak morning traffic decreased by 23 percent, and peak ozone levels dropped by 28 percent. As a result, childhood asthma-related emergency room visits fell by 42 percent.

to ozone formation (especially nitrogen oxides and volatile organic compounds [VOCs]), natural emissions of VOCs from plants, and pollution blown in from other places.[290,297] A warmer climate is projected to increase the natural emissions of VOCs, accelerate ozone formation, and increase the frequency and duration of stagnant air masses that allow pollution to accumulate, which will exacerbate health symptoms.[298] Increased temperatures and water vapor due to human-induced carbon dioxide emissions have been found to increase ozone more in areas with already elevated concentrations, meaning that global warming tends to exacerbate ozone pollution most in already polluted areas. Under constant pollutant emissions, by the middle of this century, Red Ozone Alert Days (when the air is unhealthy for everyone) in the 50 largest cities in the eastern United States are projected to increase by 68 percent due to warming alone.[298] Such conditions would challenge the ability of communities to meet health-based air quality standards such as those in the Clean Air Act.

Health risks from heat waves and air pollution are not necessarily independent. The formation of ground-level ozone occurs under hot and stagnant conditions – essentially the same weather conditions accompanying heat waves (see box page 102). Such interactions among risk factors are likely to increase as climate change continues.

Extreme weather events cause physical and mental health problems. Some of these events are projected to increase.

Injury, illness, emotional trauma, and death are known to result from extreme weather events.[68] The number and intensity of some of these events are already increasing and are projected to increase further in the future.[68,112] Human health impacts in the United States are generally expected to be less severe than in poorer countries where the emergency preparedness and public health infrastructure is less developed. For example, early warning and evacuation systems and effective sanitation lessen the health impacts of extreme events.[68]

This assumes that medical and emergency relief systems in the United States will function well and that timely and effective adaptation measures will be developed and deployed. There have already been serious failures of these systems in the aftermath of hurricanes Katrina and Rita, so coping with future impacts will require significant improvements.

Extreme storms

Over 2,000 Americans were killed in the 2005 hurricane season, more than double the average number of lives lost to hurricanes in the United States over the previous 65 years.[163] But the human health impacts of extreme storms go beyond direct injury and death to indirect effects such as carbon monoxide poisoning from portable electric generators in use following hurricanes, an increase in stomach and intestinal illness among evacuees, and mental health impacts such as depression and post-traumatic stress disorder.[163] Failure to fully account for both direct and indirect health impacts might result in inadequate preparation for and response to future extreme weather events.[163]

Floods

Heavy downpours have increased in recent decades and are projected to increase further as the world continues to warm.[68,112] In the United States, the amount of precipitation falling in the heaviest 1 percent of rain events increased by 20 percent in the past century, while total precipitation increased by 7 percent. Over the last century, there was a 50 percent increase in the frequency of days with precipitation over 4 inches in the upper Midwest.[112] Other regions, notably the South, have also seen strong increases in heavy downpours, with most of these coming in the warm season and almost all of the increase coming in the last few decades.

Heavy rains can lead to flooding, which can cause health impacts including direct injuries as well as increased incidence of waterborne diseases due to pathogens such as *Cryptosporidium* and *Giardia*.[163] Downpours can trigger sewage overflows, contaminating drinking water and endangering beachgoers. The consequences will be particularly severe in the roughly 770 U.S. cities and towns, including New York, Chicago, Washington DC, Milwaukee, and Philadelphia, that have "combined sewer systems;" an older design that carries storm water and sewage in the same pipes.[299] During heavy rains, these systems often cannot handle the volume, and raw sewage spills into lakes or waterways, including drinking-water supplies and places where people swim.[252]

In 1994, the Environmental Protection Agency (EPA) established a policy that mandates that communities substantially reduce or eliminate their combined sewer overflow, but this mandate remains unfulfilled.[300] In 2004, the EPA estimated it would cost $55 billion to correct combined sewer overflow problems in publicly owned wastewater treatment systems.[301]

Using 2.5 inches of precipitation in one day as the threshold for initiating a combined sewer overflow event, the frequency of these events in Chicago is expected to rise by 50 percent to 120 percent by the end of this century,[302] posing further risks to drinking and recreational water quality.

Wildfires

Wildfires in the United States are already increasing due to warming. In the West, there has been a nearly fourfold increase in large wildfires in recent decades, with greater fire frequency, longer fire durations, and longer wildfire seasons. This increase is strongly associated with increased spring and summer temperatures and earlier spring snowmelt, which have caused drying of soils and vegetation.[163,252,294] In addition to direct injuries and deaths due to burns, wildfires can cause eye and respiratory illnesses due to fire-related air pollution.[163]

Some diseases transmitted by food, water, and insects are likely to increase.

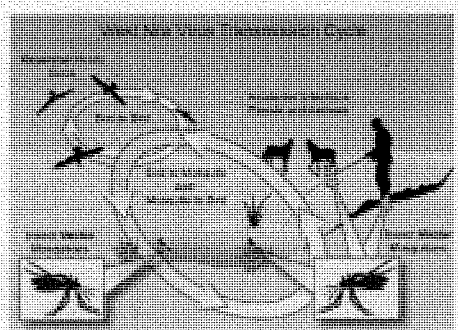
A number of important disease-causing agents (pathogens) commonly transmitted by food, water,

Spotlight on West Nile Virus

The first outbreak of West Nile virus in the United States occurred in the summer of 1999, likely a result of international air transport. Within five years, the disease had spread across the continental United States, transmitted by mosquitoes that acquire the virus from infected birds. While bird migrations were the primary mode of disease spread during the epidemic summers of 2002 to 2004, epicenters of West Nile virus were linked to locations with either drought or above average temperatures.

Since 1999, West Nile virus has caused over 28,000 reported cases, and over 1,100 Americans have died from it.[illegible] During 2002, a more virulent strain of West Nile virus emerged in the United States. Recent analyses indicate that this mutated strain responds strongly to higher temperatures, suggesting that greater risks from the disease may result from increases in the frequency of heatwaves,[illegible] though the risk will also depend on the effectiveness of mosquito control programs.

While West Nile virus causes mild flu-like symptoms in most people, about one in 150 infected people develop serious illness, including the brain inflammation diseases encephalitis and meningitis.



or animals are susceptible to changes in replication, survival, persistence, habitat range, and transmission as a result of changing climatic conditions such as increasing temperature, precipitation, and extreme weather events.[163]

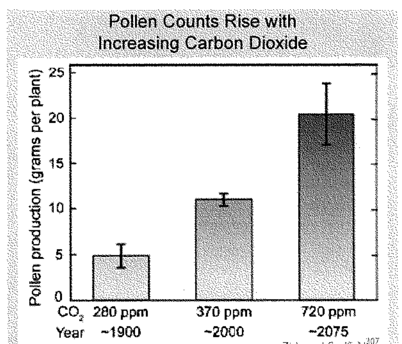
- Cases of food poisoning due to *Salmonella* and other bacteria peak within one to six weeks of the highest reported ambient temperatures.[163]
- Cases of waterborne *Cryptosporidium* and *Giardia* increase following heavy downpours. These parasites can be transmitted in drinking water and through recreational water use.[163]
- Climate change affects the life cycle and distribution of the mosquitoes, ticks, and rodents that carry West Nile virus, equine encephalitis, Lyme disease, and hantavirus. However, moderating factors such as housing quality, land use patterns, pest control programs, and a robust public health infrastructure are likely to prevent the large-scale spread of these diseases in the United States.[163,305]
- Heavy rain and flooding can contaminate certain food crops with feces from nearby livestock or wild animals, increasing the likelihood of food-borne disease associated with fresh produce.[163]
- *Vibrio* sp. (shellfish poisoning) accounts for 20 percent of the illnesses and 95 percent of the deaths associated with eating infected shellfish, although the overall incidence of illness from *Vibrio* infection remains low. There is a close association between temperature, *Vibrio* sp. abundance, and clinical illness. The U.S. infection rate increased 41 percent from 1996 to 2006,[163] concurrent with rising temperatures.
- As temperatures rise, tick populations that carry Rocky Mountain spotted fever are projected to shift from south to north.[306]
- The introduction of disease-causing agents from other regions of the world is an additional threat.[163]

While the United States has programs such as the Safe Drinking Water Act that help protect against some of these problems, climate change will present new challenges.

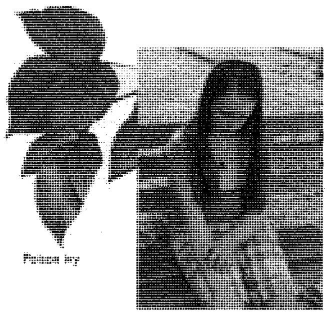
Rising temperature and carbon dioxide concentration increase pollen production and prolong the pollen season in a number of plants with highly allergenic pollen, presenting a health risk.

Rising carbon dioxide levels have been observed to increase the growth and toxicity of some plants that cause health problems. Climate change has caused an earlier onset of the spring pollen season in the United States.[272] It is reasonable to conclude that allergies caused by pollen have also experienced associated changes in seasonality.[272] Several laboratory studies suggest that increasing carbon dixoide concentrations and temperatures increase ragweed pollen production and prolong the ragweed pollen season.[163,272]

Poison ivy growth and toxicity is also greatly increased by carbon dioxide, with plants growing larger and more allergenic. These increases exceed those of most beneficial plants. For example, poison ivy vines grow twice as much per year in air with a doubled preindustrial carbon dioxide concentration as they do in unaltered air; this is nearly five times the increase reported for tree species in



Pollen production from ragweed grown in chambers at the carbon dioxide concentration of a century ago (about 280 parts per million [ppm]) was about 5 grams per plant; at today's approximate carbon dioxide level, it was about 10 grams; and at a level projected to occur about 2075 under the higher emissions scenario,[91] it was about 20 grams.[307]



other analyses.[308] Recent and projected increases in carbon dioxide also have been shown to stimulate tbe growth of stinging nettle and leafy spurge, two weeds that cause rashes when they come into contact with human skin.[309,310]

Certain groups, including children, the elderly, and the poor, are most vulnerable to a range of climate-related health effects.

Infants and children, pregnant women, the elderly, people with chronic medical conditions, outdoor workers, and people living in poverty are especially at risk from a variety of climate related health effects. Examples of these effects include increasing heat stress, air pollution, extreme weather events, and diseases carried by food, water, and insects.[163]

Children's small ratio of body mass to surface area and other factors make them vulnerable to heat-related illness and death. Their increased breathing rate relative to body size, additional time spent outdoors, and developing respiratory tracts, heighten their sensitivity to air pollution. In addition, children's immature immune systems increase their risk of serious consequences from waterborne and food-borne diseases, while developmental factors make them more vulnerable to complications from severe infections such as *E. coli* or *Salmonella*.[163]

The greatest health burdens related to climate change are likely to fall on the poor, especially those lacking adequate shelter and access to other resources such as air conditioning.[163]

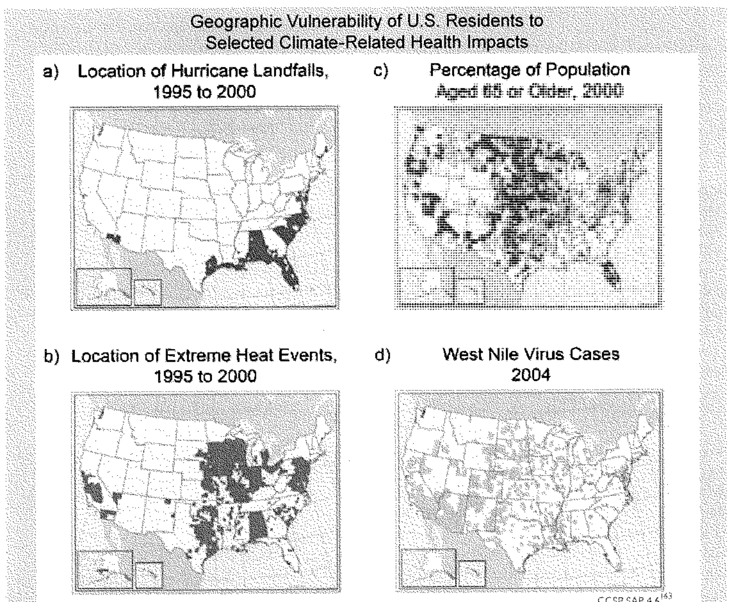
Elderly people are more likely to have debilitating chronic diseases or limited mobility. The elderly are also generally more sensitive to extreme heat for several reasons. They have a reduced ability to regulate their own body temperature or sense when they are too hot. They are at greater risk of heart failure, which is further exacerbated when cardiac demand increases in order to cool the body during a heat wave.[318] Also, people taking medications, such as diuretics for high blood pressure, have a higher risk of dehydration.[163]

The multiple health risks associated with diabetes will increase the vulnerability of the U.S. population to increasing temperatures. The number of Americans with diabetes has grown to about 24 million people, or roughly 8 percent of the U.S. population. Almost 25 percent of the population 60 years and older had diabetes in 2007.[311] Fluid imbalance and dehydration create higher risks for diabetics during heat waves. People with diabetes-related heart disease are at especially increased risk of dying in heat waves.[318]

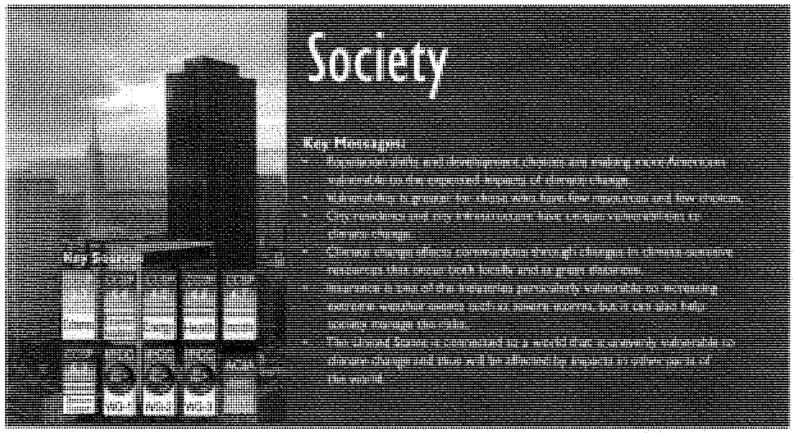
High obesity rates in the United States are a contributing factor in currently high levels of diabetes. Similarly, a factor in rising obesity rates is a sedentary lifestyle and automobile dependence; 60 percent of Americans do not meet minimum daily exercise requirements. Making cities more walkable and bikeable would thus have multiple benefits: improved personal fitness and weight loss;

reduced local air pollution and associated respiratory illness; and reduced greenhouse gas emissions.[312]

The United States has considerable capacity to adapt to climate change, but during recent extreme weather and climate events, actual practices have not always protected people and property. Vulnerability to extreme events is highly variable, with disadvantaged groups and communities (such as the poor, infirm, and elderly) experiencing considerable damage and disruptions to their lives. Adaptation tends to be reactive, unevenly distributed, and focused on coping rather than preventing problems. Future reduction in vulnerability will require consideration of how best to incorporate planned adaptation into long-term municipal and public service planning, including energy, water, and health services, in the face of changing climate-related risks combined with ongoing changes in population and development patterns.[163,164]



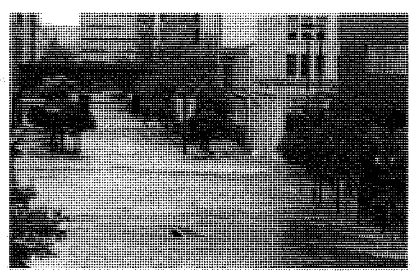
Maps indicating U.S. counties, or in some cases states, with existing vulnerability to climate-sensitive health outcomes: a) location of hurricane landfalls; b) extreme heat events (defined by the Centers for Disease Control as temperatures 10 or more degrees F above the average high temperature for the region and lasting for several weeks); c) percentage of population over age 65 (dark blue indicates that percentage is over 17.6 percent, light blue 14.4 to 17.5 percent); d) locations of West Nile virus cases reported in 2004. These examples demonstrate both the diversity of climate-sensitive health outcomes and the geographic variability of where they occur. Events over short time spans, in particular West Nile virus cases, are not necessarily predictive of future vulnerability.



Climate change will affect society through impacts on the necessities and comforts of life: water, energy, housing, transportation, food, natural ecosystems, and health. This section focuses on some characteristics of society that make it vulnerable to the potential impacts of climate change and how the risks and costs may be distributed. Many impacts of climate change on society, for example, sea-level rise and increased water scarcity, are covered in other sections of this report. This section is not a comprehensive analysis of societal vulnerabilities, but rather highlights key examples.

Because societies and their built environments have developed under a climate that has fluctuated within a relatively confined range of conditions, most impacts of a rapidly changing climate will present challenges. Society is especially vulnerable to extremes, such as heat waves and floods, many of which are increasing as climate changes.[313] And while there are likely to be some benefits and opportunities in the early stages of warming, as climate continues to change, negative impacts are projected to dominate.[164]

Climate change will affect different segments of society differently because of their varying exposures and adaptive capacities. The impacts of climate change also do not affect society in isolation. Rather, impacts can be exacerbated when climate change occurs in combination with the effects of an aging and growing population, pollution, poverty, and natural environmental fluctuations.[164,172,274] Unequal adaptive capacity in the world as a whole also will pose challenges to the United States. Poorer countries are projected to be disproportionately affected by the impacts of climate change and the United States is strongly connected to the world beyond its borders through markets, trade, investments, shared resources, migrating species, health, travel and tourism, environmental refugees (those fleeing deteriorating environmental conditions), and security.



Cedar Rapids, Iowa, June 12, 2008

Population shifts and development choices are making more Americans vulnerable to the expected impacts of climate change.

Climate is one of the key factors in Americans' choices of where to live. As the U.S. population grows, ages, and becomes further concentrated in cities and coastal areas, society is faced with additional challenges. Climate change is likely to exacerbate these challenges as changes in temperature, precipitation, sea levels, and extreme weather events increasingly affect homes, communities, water supplies, land resources, transportation, urban infrastructure, and regional characteristics that people have come to value and depend on.

Population growth in the United States over the past century has been most rapid in the South, near the coasts, and in large urban areas (see figure on page 55 in the *Energy* sector). The four most populous states in 2000 – California, Texas, Florida, and New York – accounted for 38 percent of the total growth in U.S. population during that time, and share significant vulnerability to coastal storms, severe drought, sea-level rise, air pollution, and urban heat island effects.[313] But migration patterns are now shifting: the population of the Mountain West (Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico) is projected to increase by 65 percent from 2000 to 2030, representing one-third of all U.S. population growth.[274,314] Southern coastal areas on both the Atlantic and the Gulf of Mexico are projected to continue to see population growth.[313]

Overlaying projections of future climate change and its impacts on expected changes in U.S. population and development patterns reveals a critical insight: more Americans will be living in the areas that are most vulnerable to the effects of climate change.[274]

America's coastlines have seen pronounced population growth in regions most at risk of hurricane activity, sea-level rise, and storm surge – putting more people and property in harm's way as the probability of harm increases.[274] On the Atlantic and Gulf coasts where hurricane activity is prevalent, the coastal land in many areas is sinking while sea level is rising. Human activities are exacerbating the loss of coastal wetlands that once helped buffer the coastline from erosion due to storms. The devastation caused by recent hurricanes highlights the vulnerability of these areas.[224]

The most rapidly growing area of the country is the Mountain West, a region projected to face more frequent and severe wildfires and have less water available, particularly during the high-demand period of summer. Continued population growth in these arid and semi-arid regions would stress water supplies. Because of high demand for irrigating agriculture, overuse of rivers and streams is common in the arid West, particularly along the Front Range of the Rocky Mountains in Colorado, in Southern California, and in the Central Valley of California. Rapid population and economic growth in these arid and semi-arid regions has dramatically increased vulnerability to water shortages (see *Water Resources* sector and *Southwest* region).[274]

Many questions are raised by ongoing development patterns in the face of climate change. Will growth continue as projected in vulnerable areas, despite the risks? Will there be a retreat from the coastline as it becomes more difficult to insure vulnerable properties? Will there be pressure for the government to insure properties that private insurers have rejected? How can the vulnerability of new development be minimized? How can we ensure that communities adopt measures to manage the significant changes that are projected in sea level, temperature, rainfall, and extreme weather events?

Development choices are based on people's needs and desires for places to live, economies that provide employment, ecosystems that provide services, and community-based social activities. Thus, the future vulnerability of society will be influenced by how and where people choose to live. Some choices, such as expanded development in coastal regions, can increase vulnerabilities to climate-related events, even without any change in climate.

Vulnerability is greater for those who have few resources and few choices.

Vulnerabilities to climate change depend not only on where people are but also on their circumstances. In general, groups that are especially vulnerable include the very young, the very old, the sick, and the poor. These groups represent a more significant portion of the total population in some regions and localities than others. For example, the elderly more often cite a warm climate as motivating their choice of where to live and thus make up a larger share of the population in warmer areas.[305]

In the future (as in the past), the impacts of climate change are likely to fall disproportionately on the disadvantaged.[313] People with few resources often live in conditions that increase their vulnerability to the effects of climate change.[172] For example, the experience with Hurricane Katrina showed that the poor and elderly were the most vulnerable because of where they lived and their limited ability to get out of harm's way. Thus, those who had the least proportionately lost the most. And it is clear that people with access to financial resources, including insurance, have a greater capacity to adapt to, recover, or escape from adverse impacts of climate change than those who do not have such access.[305, 316] The fate of the poor can be permanent dislocation, leading to the loss of social relationships and community support networks provided by schools, churches, and neighborhoods.

Native American communities have unique vulnerabilities. Native Americans who live on established reservations are restricted to reservation boundaries and therefore have limited relocation options.[219] In Alaska, over 100 villages on the coast and in low-lying areas along rivers are subject to increased flooding and erosion due to warming.[315] Warming also reduces the availability and accessibility of many traditional food sources for Native Alaskans, such as seals that live on ice and caribou whose migration patterns depend on being able to cross frozen rivers and wetlands. These vulnerable people face losing their current livelihoods, their communities, and in some cases, their culture, which depends on traditional ways of collecting and sharing food.[132,220] Native cultures in the Southwest are particularly vulnerable to impacts of climate change on water quality and availability.

Chalmette, Louisiana after Hurricane Katrina

City residents and city infrastructure have unique vulnerabilities to climate change.

Over 80 percent of the U.S. population resides in urban areas, which are among the most rapidly changing environments on Earth. In recent decades, cities have become increasingly spread out, complex, and interconnected with regional and national economies and infrastructure.[319] Cities also experience a host of social problems, including neighborhood degradation, traffic congestion, crime, unemployment, poverty, and inequities in health and well-being.[320] Climate-related changes such as increased heat, water shortages, and extreme weather events will add further stress to existing problems. The impacts of climate change on cities are compounded by aging infrastructure, buildings, and populations, as well as air pollution and population growth. Further, infrastructure designed to handle past variations in climate can instill a false confidence in its ability to handle future changes. However, urban areas also present opportunities for adaptation through technology, infrastructure, planning, and design.[313]

As cities grow, they alter local climates through the urban heat island effect. This effect occurs because cities absorb, produce, and retain more heat than the surrounding countryside. The urban heat island effect has raised average urban air temperatures by 2 to 5°F more than surrounding areas over the past 100 years, and by up to 20°F more at night.[321] Such temperature increases, on top of the general increase caused by human-induced warming, affect urban dwellers in many ways, influencing health, comfort, energy costs, air quality, water quality and availability, and even violent crime (which increases at high temperatures) (see *Human Health, Energy,* and *Water Resources* sectors).[172,313,322,323]

More frequent heavy downpours and floods in urban areas will cause greater property damage, a heavier burden on emergency management, increased clean-up and rebuilding costs, and a growing financial toll on businesses and homeowners. The Midwest floods of 2008 provide a recent vivid example of such tolls. Heavy downpours and urban floods can also overwhelm combined sewer and storm-water systems and release pollutants to waterways.[313] Unfortunately, for many cities, current planning and existing infrastructure are designed for the historical one-in-100 year event, whereas cities are likely to experience this same flood level much more frequently as a result of the climate change projected over this century.[146,164,324]

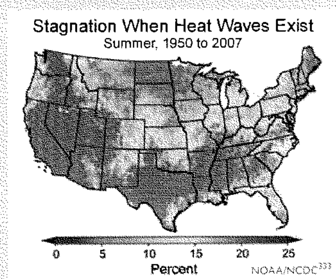
Cities are also likely to be affected by climate change in unforeseen ways, necessitating diversion of city funds for emergency responses to extreme weather.[313] There is the potential for increased summer electricity blackouts owing to greater demand for air conditioning.[325] For example, there were widespread power outages in Chicago during the 1995 heat wave and in some parts of New York City during the 1999 heat wave. In southern California's cities, additional summer electricity demand will intensify conflicts between hydropower and flood-control objectives.[164] Increased costs of repairs and maintenance are projected for transportation systems, including roads, railways, and airports, as they are negatively affected by heavy downpours

Heat, Drought, and Stagnant Air Degrade Air Quality and Quality of Life

Heat waves and poor air quality already threaten the lives of thousands of people each year.[292] Experience and research have shown that these events are interrelated as the atmospheric conditions that produce heat waves are often accompanied by stagnant air and poor air quality.[326] The simultaneous occurrence of heat waves, drought, and stagnant air negatively affects quality of life, especially in cities.

One such event occurred in the United States during the summer of 1988, causing 5,000 to 10,000 deaths and economic losses of more than $70 billion (in 2002 dollars).[229,327] Half of the nation was affected by drought, and 5,994 all-time daily high temperature records were set around the country in July alone (more than three times the most recent 10-year average).[328,329] Poor air quality resulting from the lack of rainfall, high temperatures, and stagnant conditions led to an unprecedented number of unhealthy air quality days throughout large parts of the country.[327,329] Continued climate change is projected to increase the likelihood of such episodes.[68,330]

Interactions such as those between heat wave and drought will affect adaptation planning. For example, electricity use increases during heat waves due to increased air conditioning demand.[330,331] During droughts, cooling water availability is at its lowest. Thus, during a simultaneous heat wave and drought, electricity demand for cooling will be high when power plant cooling water availability is at its lowest.[340]



The map shows the frequency of occurrence of stagnant air conditions when heat wave conditions were also present. Since 1950, across the Southeast, southern Great Plains, and most of the West, the air was stagnant more than 25 percent of the time during heat waves.

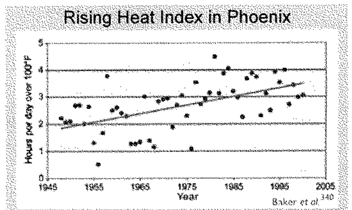
and extreme heat[190] (see *Transportation* sector). Coping with increased flooding will require replacement or improvements in storm drains, flood channels, levees, and dams.

In addition, coastal cities are also vulnerable to sea-level rise, storm surge, and increased hurricane intensity. Cities such as New Orleans, Miami, and New York are particularly at risk, and would have difficulty coping with the sea-level rise projected by the end of the century under a higher emissions scenario.[91,164] Remnants of hurricanes moving inland also threaten cities of the Appalachian Mountains, which are vulnerable if hurricane frequency or intensity increases. Since most large U.S. cities are on coasts, rivers, or both, climate change will lead to increased potential flood damage. The largest impacts are expected when sea-level rise, heavy runoff, high tides, and storms coincide.[313] Analyses of New York and Boston indicate that the potential impacts of climate change are likely to be negative, but that vulnerability can be reduced by behavioral and policy changes.[313,334-336]

Urban areas concentrate the human activities that are largely responsible for heat-trapping emissions. The demands of urban residents are also associated with a much larger footprint on areas far removed from these population centers.[337] On the other hand, concentrating activities such as transportation can make them more efficient. Cities have a large role to play in reducing heat-trapping emissions, and many are pursuing such actions. For example, over 900 cities have committed to the U.S. Mayors' Climate Protection Agreement to advance emissions reduction goals.[317]

Cities also have considerable potential to adapt to climate change through technological, institutional, structural, and behavioral changes. For example, a number of cities have warning programs in place to reduce heat-related illness and death (see *Human Health* sector). Relocating development away from low-lying areas, building new infrastructure with future sea-level rise in mind, and promoting water conservation are examples of structural and institutional strategies. Choosing road materials that can handle higher temperatures is an adaptation option that relies on new technology (see *Transportation* sector). Cities can reduce heat loads by increasing

Rising Heat Index in Phoenix



The average number of hours per summer day in Phoenix that the temperature was over 100°F has doubled over the past 50 years, in part as a result of the urban heat island effect. Hot days take a toll on both quality of life and loss of life. Arizona's heat-related deaths are the highest of any state, at three to seven times the national average.[340,341]

reflective surfaces and green spaces. Some actions have multiple benefits. For example, increased planting of trees and other vegetation in cities has been shown to be associated with a reduction in crime,[338] in addition to reducing local temperatures, and thus energy demand for air conditioning.

Human well-being is influenced by economic conditions, natural resources and amenities, public health and safety, infrastructure, government, and social and cultural resources. Climate change will influence all of these, but an understanding of the many interacting impacts, as well as the ways society can adapt to them, remains in its infancy.[305,339]

Climate change affects communities through changes in climate-sensitive resources that occur both locally and at great distances.

Human communities are intimately connected to resources beyond their geographical boundaries. Thus, communities will be vulnerable to the potential impacts of climate change on sometimes-distant resources. For example, communities that have developed near areas of agricultural production, such as the Midwest corn belt or the wine-producing regions of California and the Northwest, depend on the continued productivity of those regions, which would be compromised by increased temperature or severe weather.[313] Some agricultural production that is linked to cold climates is likely to disappear entirely: recent warming has altered the required temperature patterns for maple syrup production, shifting production northward from New England into Canada. Similarly, cranberries require a long winter chill period, which is shrinking as climate warms[234] (see *Northeast* region). Most cities depend on water supplies from distant watersheds, and those depending on diminishing supplies (such as the Sierra Nevada snowpack) are vulnerable. Northwest communities also depend upon forest resources for their economic base, and many island, coastal, and "sunbelt" communities depend on tourism.

Recreation and tourism play important roles in the economy and quality of life of many Americans. In some regions tourism and recreation are major job creators, bringing billions of dollars to regional economies. Across the nation, fishing, hunting, skiing, snowmobiling, diving, beach-going, and other outdoor activities make important economic contributions and are a part of family traditions that have value that goes beyond financial returns. A changing climate will mean reduced opportunities for some activities and locations and expanded opportunities for others.[305,342] Hunting and fishing will change as animals' habitats shift and as relationships among species in natural communities are disrupted by their different responses to rapid climate change. Water-dependent recreation in areas projected to get drier, such as the Southwest, and beach recreation in areas that are expected to see rising sea levels, will suffer. Some regions will see an expansion of the season for warm weather recreation such as hiking and bicycle riding.

Examples of Impacts On Recreation

Recreational Activity	Potential Impacts of Climate Change	Estimated Economic Impacts
Skiing, Northeast	20 percent reduction in ski season length	$800 million loss per year, potential resort closures
Snowmobiling, Northeast	Reduction of season length under higher emissions scenario	Complete loss of opportunities in New York and Pennsylvania within a few decades, 80 percent reduction in season length for region by end of century
Beaches, North Carolina	More beaches are eroded, and some lost by 2080	Reduced opportunities for beach and fishing trips, without additional costs for adaptation measures

Insurance is one of the industries particularly vulnerable to increasing extreme weather events such as severe storms, but it can also help society manage the risks.

Insurance – the world's largest industry – is one of the primary mechanisms through which the costs of climate change are distributed across society.[344,351]

Most of the climate change impacts described in this report have economic consequences. A significant portion of these flow through public and private insurance markets, which essentially aggregate and distribute society's risk. Insurance thus provides a window into the myriad ways in which the costs of climate change will manifest, and serves as a form of economic adaptation and a messenger of these impacts through the terms and price signals it sends its customers.[344]

In an average year, about 90 percent of insured catastrophe losses worldwide are weather-related. In the United States, about half of all these losses are insured, which amounted to $320 billion between 1980 and 2005 (inflation-adjusted to 2005 dollars). While major events such as hurricanes grab headlines, the aggregate effect of smaller events accounts for at least 60 percent of total insured losses on average.[344] Many of the smallest scale property losses and weather-related life/health losses are unquantified.[345]

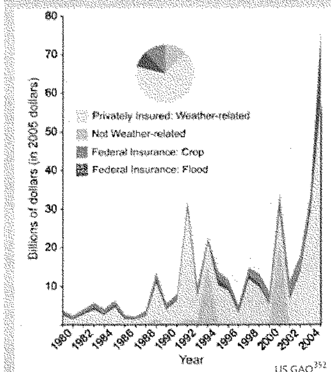
Escalating exposures to catastrophic weather events, coupled with private insurers' withdrawal from various markets, are placing the federal government at increased financial risk as insurer of last resort. The National Flood Insurance Program would have gone bankrupt after the storms of 2005 had they not been given the ability to borrow about $20 billion from the U.S. Treasury.[172] For public and private insurance programs alike, rising losses require a combination of risk-based premiums and improved loss prevention.

While economic and demographic factors have no doubt contributed to observed increases in losses,[346] these factors do not fully explain the upward trend in costs or numbers of events.[344,347] For example, during the time period covered in the figure to the right, population increased by a factor of 1.3 while losses increased by a factor of 15 to 20 in inflation-corrected dollars. Analyses asserting little or no role of climate change in increasing the risk of losses tend to focus on a highly limited set of hazards and locations. They also often fail to account for the vagaries of natural cycles and inflation adjustments, or to normalize for countervailing factors such as improved pre- and post-event loss prevention (such as dikes, building codes, and early warning systems).[348]

What is known with far greater certainty is that future increases in losses will be attributable to climate change as it increases the frequency and intensity of many types of extreme weather, such as severe thunderstorms and heat waves.[131,350]

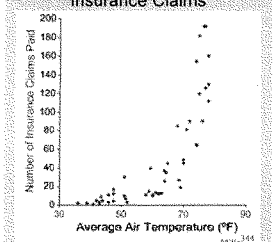
Insurance is emblematic of the increasing globalization of climate risks. Because large U.S.-based companies operate around the world, their customers and assets are exposed to climate impacts wherever they occur. Most of the growth in the insurance industry is in emerging markets, which will structurally increase U.S. insurers' exposure to climate risk because those regions are more vulnerable and are experiencing particularly high rates of population growth and development.[351]

Insured Losses from Catastrophes, 1980 to 2005



Weather-related insurance losses in the United States are increasing. Typical weather-related losses today are similar to those that resulted from the 9/11 attack (shown in gray at 2001 in the graph). About half of all economic losses are insured, so actual losses are roughly twice those shown on the graph. Data on smaller-scale losses (many of which are weather-related) are significant but are not included in this graph as they are not comprehensively reported by the U.S. insurance industry.

Lightning-Related Insurance Claims



There is a strong observed correlation between higher temperatures and the frequency of lightning-induced insured losses in the United States. Each marker represents aggregate monthly U.S. lightning-related insurance claims paid by one large national insurer over a five-year period, 1991-1995. All else being equal, these claims are expected to increase with temperature.[344,353,354]

The movement of populations into harm's way creates a rising baseline of insured losses upon which the consequences of climate change will be superimposed. These observations reinforce a recurring theme in this report: the past can no longer be used as the basis for planning for the future.

It is a challenge to design insurance systems that properly price risks, reward loss prevention, and do not foster risk taking (for example by repeatedly rebuilding flooded homes). This challenge is particularly acute in light of insurance market distortions such as prices that inhibit insurers' ability to recover rising losses, combined with information gaps on the impacts of climate change and adaptation strategies. Rising losses[252] are already affecting the availability and affordability of insurance. Several million customers in the United States, no longer able to purchase private insurance coverage, are taking refuge in state-mandated insurance pools, or going without insurance altogether. Offsetting rising insurance costs is one benefit of mitigation and adaptation investments to reduce the impacts of climate change.

Virtually all segments of the insurance industry are vulnerable to the impacts of climate change. Examples include damage to property, crops, forest products, livestock, and transportation infrastructure; business and supply-chain interruptions caused by weather extremes, water shortages, and electricity outages; legal consequences;[355] and compromised health or loss of life. Increasing risks to insurers and their customers are driven by many factors including reduced periods of time between loss events, increasing variability, shifting types and location of events, and widespread simultaneous losses.

In light of these challenges, insurers are emerging as partners in climate science and the formulation of public policy and adaptation strategies.[356] Some have promoted adaptation by providing premium incentives for customers who fortify their properties, engaging in the process of determining building codes and land-use plans, and participating in the development and financing of new technologies and practices. For example, the Federal Emergency Management Agency (FEMA) Community Rating System is a point system that rewards communities that undertake floodplain management activities to reduce flood risk beyond the minimum requirement set by the National Flood Insurance Program. Everyone in these communities is rewarded with lower flood insurance premiums (−5 to −45 percent).[357] Others have recognized that mitigation and adaptation can work hand in hand in a coordinated climate risk-management strategy and are offering "green" insurance products designed to capture these dual benefits.[351,349]

The United States is connected to a world that is unevenly vulnerable to climate change and thus will be affected by impacts in other parts of the world.

American society will not experience the potential impacts of climate change in isolation. In an increasingly connected world, impacts elsewhere will have political, social, economic, and environmental ramifications for the United States. As in the United States, vulnerability to the potential impacts of climate change worldwide varies by location, population characteristics, and economic status.

The rising concentration of people in cities is occurring globally, but is most prevalent in lower-income countries. Many large cities are located in vulnerable areas such as floodplains and coasts. In most of these cities, the poor often live in the most marginal of these environments, in areas that are susceptible to extreme events, and their ability to adapt is limited by their lack of financial resources.[172]

In addition, over half of the world's population – including most of the world's major cities – depends on glacier melt or snowmelt to supply water for drinking and municipal uses. Today, some locations are experiencing abundant water supplies and even frequent floods due to increases in glacier melt rates due to increased temperatures worldwide. Soon, however, this trend is projected to reverse as even greater temperature increases reduce glacier mass and cause more winter precipitation to fall as rain and less as snow.[90]

As conditions worsen elsewhere, the number of people wanting to immigrate to the United States will increase. The direct cause of potential increased migration, such as extreme climatic events, will be difficult to separate from other forces that drive people to migrate. Climate change also has the potential to alter trade relationships by changing the comparative trade advantages of regions or nations. As with migration, shifts in trade can have multiple causes.

Accelerating emissions in economies that are rapidly expanding, such as China and India, pose future threats to the climate system and already are associated with air pollution episodes that reach the United States.[297]

Meeting the challenge of improving conditions for the world's poor has economic implications for the United States, as does intervention and resolution of intra- and intergroup conflicts. Where climate change exacerbates such challenges, for example by limiting access to scarce resources or increasing incidence of damaging weather events, consequences are likely for the U.S. economy and security.[358]

Northeast

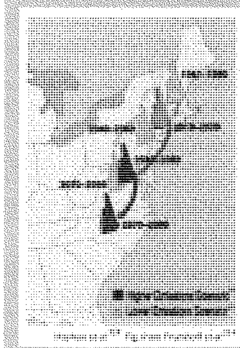
The Northeast has significant geographic and climatic diversity within its relatively small area. The character and economy of the Northeast have been shaped by many aspects of its climate including its snowy winters, colorful autumns, and variety of extreme events such as nor'easters, ice storms, and heat waves. This familiar climate has already begun changing in noticeable ways.

Since 1970, the annual average temperature in the Northeast has increased by 2°F, with winter temperatures rising twice this much.[150] Warming has resulted in many other climate-related changes, including:

- More frequent days with temperatures above 90°F
- A longer growing season
- Increased heavy precipitation
- Less winter precipitation falling as snow and more as rain
- Reduced snowpack
- Earlier breakup of winter ice on lakes and rivers
- Earlier spring snowmelt resulting in earlier peak river flows
- Rising sea surface temperatures and sea level

Each of these observed changes is consistent with the changes expected in this region from global warming. The Northeast is projected to face continued warming and more extensive climate-related changes, some of which could dramatically alter the region's economy, landscape, character, and quality of life.

Climate on the Move: Changing Summers in New Hampshire



Yellow arrows track what summers are projected to feel like under a lower emissions scenario,[91] while red arrows track projections for a higher emissions scenario[91] (referred to as "even higher" on page 23). For example, under the higher emission scenario,[91] by late this century residents of New Hampshire would experience a summer climate more like what occurs today in North Carolina.[359]

Over the next several decades, temperatures in the Northeast are projected to rise an additional 2.5 to 4°F in winter and 1.5 to 3.5°F in summer. By mid-century and beyond, however, today's emissions choices would generate starkly different climate futures; the lower the emissions, the smaller the climatic changes and resulting impacts.[150,359] By late this century, under a higher emissions scenario[91]:

- Winters in the Northeast are projected to be much shorter with fewer cold days and more precipitation.
- The length of the winter snow season would be cut in half across northern New York, Vermont, New Hampshire, and Maine, and reduced to a week or two in southern parts of the region.
- Cities that today experience few days above 100°F each summer would average 20 such days per summer, while certain cities, such as Hartford and Philadelphia, would average nearly 30 days over 100°F.
- Short-term (one- to three-month) droughts are projected to occur as frequently as once each summer in the Catskill and Adirondack Mountains, and across the New England states.
- Hot summer conditions would arrive three weeks earlier and last three weeks longer into the fall.
- Sea level in this region is projected to rise more than the global average, see *Global* and *National Climate Change* and *Coasts* sections for more information on sea-level rise (pages 25, 37, 150).

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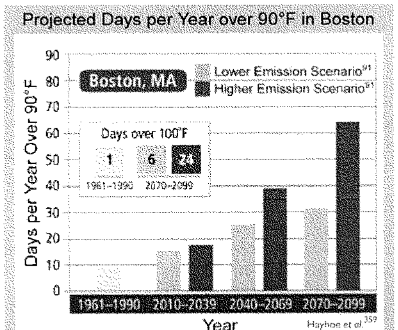
Extreme heat and declining air quality are likely to pose increasing problems for human health, especially in urban areas.

Heat waves, which are currently rare in the region, are projected to become much more commonplace in a warmer future, with major implications for human health (see *Human Health* sector).[163,68]

In addition to the physiological stresses associated with hotter days and nights,[360] for cities that now experience ozone pollution problems, the number of days that fail to meet federal air quality standards is projected to increase with rising temperatures if there are no additional controls on ozone-causing pollutants[163,361] (see *Human Health* sector). Sharp reductions in emissions will be needed to keep ozone within existing standards.

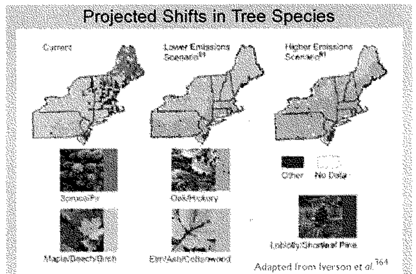
Projected changes in summer heat (see figure below) provide a clear sense of how different the climate of the Northeast is projected to be under lower versus higher emissions scenarios. Changes of this kind will require greater use of air conditioning (see *Energy* sector).

Projected Days per Year over 90°F in Boston



The graph shows model projections of the number of summer days with temperatures over 90°F in Boston, Massachusetts, under lower and higher (referred to as "even higher" on page 23) emissions scenarios.[91] The inset shows projected days over 100°F.[359]

Projected Shifts in Tree Species



Much of the Northeast's forest is composed of the hardwoods maple, beech, and birch, while mountain areas and more northern parts of the region are dominated by spruce/fir forests. As climate changes over this century, suitable habitat for spruce and fir is expected to contract dramatically. Suitable maple/beech/birch habitat is projected to shift significantly northward under a higher emissions scenario (referred to as "even higher" on page 23),[91] but to shift far less under a lower emissions scenario.[91,363] Other studies of tree species shifts suggest even more dramatic changes than those shown here (see page 81).

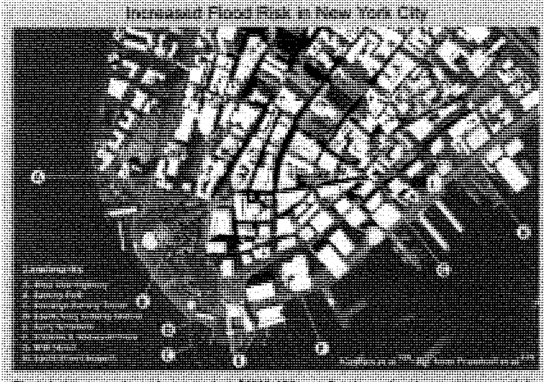
Agricultural production, including dairy, fruit, and maple syrup, are likely to be adversely affected as favorable climates shift.

Large portions of the Northeast are likely to become unsuitable for growing popular varieties of apples, blueberries, and cranberries under a higher emissions scenario.[91,362,363] Climate conditions suitable for maple/beech/birch forests are projected to shift dramatically northward (see figure above), eventually leaving only a small portion of the Northeast with a maple sugar business.[364]

The dairy industry is the most important agricultural sector in this region, witb annual production worth $3.6 billion.[365] Heat stress in dairy cows depresses both milk production and birth rates for periods of weeks to months.[193,366] By late this century, all but the northern parts of Maine, New Hampshire, New York, and Vermont are projected to suffer declines in July milk production under the higher emissions scenario. In parts of Connecticut, Massachusetts, New Jersey, New York, and Pennsylvania, a large decline in milk production, up to 20 percent or greater, is projected. Under the lower emissions scenario, however, reductions in milk production of up to 10 percent remain confined primarily to the southern parts of the region.

This analysis used average monthly temperature and humidity data that do not capture daily variations in heat stress and projected increases in extreme heat. Nor did the analysis directly consider farmer responses, such as installation of potentially costly cooling systems. On balance, these projections are likely to underestimate impacts on the dairy industry.[150]

Increased Flood Risk in New York City



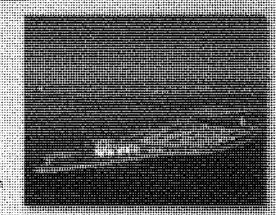
The light blue area above depicts today's FEMA 100-year flood zone for the city (the area of the city that is expected to be flooded once every 100 years). With rising sea levels, a 100-year flood at the end of this century (not mapped here) is projected to inundate a far larger area of New York City, especially under the higher emissions scenario.[91] Critical transportation infrastructure located in the Battery area of lower Manhattan could be flooded far more frequently unless protected. The increased likelihood of flooding is causing planners to look into building storm-surge barriers in New York Harbor to protect downtown New York City.

Severe flooding due to sea-level rise and heavy downpours is likely to occur more frequently.

The densely populated coasts of the Northeast face substantial increases in the extent and frequency of storm surge, coastal flooding, erosion, property damage, and loss of wetlands.[367,369] New York state alone has more than $2.3 trillion in insured coastal property.[368] Much of this coastline is exceptionally vulnerable to sea-level rise and related impacts. Some major insurers have withdrawn coverage from thousands of homeowners in coastal areas of the Northeast, including New York City.

Rising sea level is projected to increase the frequency and severity of damaging storm surges and flooding. Under a higher emissions scenario,[91] what is now considered a once-in-a-century coastal flood in New York City is projected to occur at least twice as often by mid-century, and 10 times as often (or once per decade

Adapting: Raising a Sewage Treatment Plant in Boston



Boston's Deer Island sewage treatment plant was designed and built taking future sea-level rise into consideration. Because the level of the plant relative to the level of the ocean at the outfall is critical to the amount of rainwater and sewage that can be treated, the plant was built 1.9 feet higher than it would otherwise have been to accommodate the amount of sea-level rise projected to occur by 2050, the planned life of the facility.

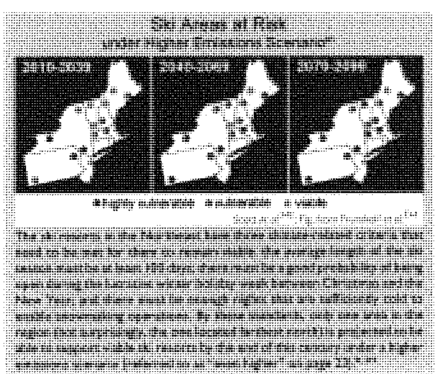
The planners recognized that the future would be different from the past and they decided to plan for the future based on the best available information. They assessed what could be easily and inexpensively changed at a later date versus those things that would be more difficult and expensive to change later. For example, increasing the plant's height would be less costly to incorporate in the original design, while protective barriers could be added at a later date, as needed, at a relatively small cost.

on average) by late this century. With a lower emissions scenario,[91] today's 100-year flood is projected to occur once every 22 years on average by late this century.[369]

The projected reduction in snow cover will adversely affect winter recreation and the industries that rely upon it.

Winter snow and ice sports, which contribute some $7.6 billion annually to the regional economy, will be particularly affected by warming.[342] Of this total, alpine skiing and other snow sports (not including snowmobiling) account for $4.6 billion annually. Snowmobiling, which now rivals skiing as the largest winter recreation industry in the nation, accounts for the remaining $3 billion.[372] Other winter traditions, ranging from skating and ice fishing on frozen ponds and lakes, to cross-country (Nordic) skiing, snowshoeing, and dog sledding, are integral to the character of the Northeast, and for many residents and visitors, its desirable quality of life.

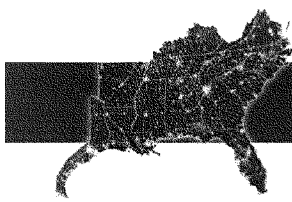
Warmer winters will shorten the average ski and snowboard seasons, increase artificial snowmaking requirements, and drive up operating costs. While snowmaking can enhance the prospects for ski resort success, it requires a great deal of water and energy, as well as very cold nights, which are becoming less frequent. Without the opportunity to benefit from snowmaking, the prospects for the snowmobiling industry are even worse. Most of the region is likely to have a marginal or non-existent snowmobile season by mid-century.



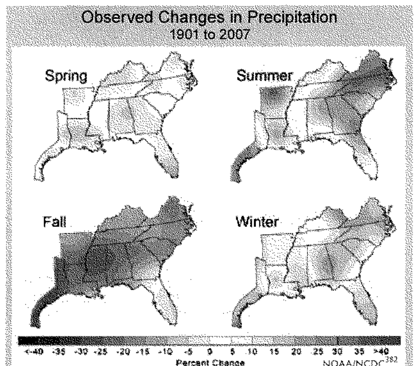
The center of lobster fisheries is projected to continue its northward shift and the cod fishery on Georges Bank is likely to be diminished.

Lobster catch has increased dramatically in the Northeast as a whole over the past three decades, though not uniformly.[374,375] Catches in the southern part of the region peaked in the mid-1990s, and have since declined sharply, beginning with a 1997 die-off in Rhode Island and Buzzards Bay (Massachusetts) associated with the onset of a temperature-sensitive bacterial shell disease, and accelerated by a 1999 lobster die-off in Long Island Sound. Currently, the southern extent of the commercial lobster harvest appears to be limited by this temperature-sensitive shell disease, and these effects are expected to increase as near-shore water temperatures rise above the threshold for this disease. Analyses also suggest that lobster survival and settlement in northern regions of the Gulf of Maine could be increased by warming water, a longer growing season, more rapid growth, an earlier hatching season, an increase in nursery grounds suitable for larvae, and faster development of plankton.[376]

Cod populations throughout the North Atlantic are adapted to a wide range of seasonal ocean temperatures, including average annual temperatures near the seafloor ranging from 36 to 54°F. Large populations of cod are generally not found above the 54°F threshold.[377] Temperature also influences both the location and timing of spawning, which in turn affects the subsequent growth and survival of young cod. Increases in average annual bottom temperatures above 47°F lead to a decline in growth and survival.[378,379] Projections of warming indicate that both the 47°F and the 54°F thresholds will be met or exceeded in this century under a higher emissions scenario.[234] Climate change will thus introduce an additional stress to an already-stressed fishery.[377]



Southeast



While average fall precipitation in the Southeast increased by 30 percent since the early 1900s, summer and winter precipitation declined by nearly 10 percent in the eastern part of the region. Southern Florida has experienced a nearly 10 percent drop in precipitation in spring, summer, and fall. The percentage of the Southeast region in drought has increased over recent decades.

The climate of the Southeast is uniquely warm and wet, with mild winters and high humidity, compared with the rest of the continental United States. The average annual temperature of the Southeast did not change significantly over the past century as a whole. Since 1970, however, annual average temperature has risen about 2°F, with the greatest seasonal increase in temperature occurring during the winter months. The number of freezing days in the Southeast has declined by four to seven days per year for most of the region since the mid-1970s.

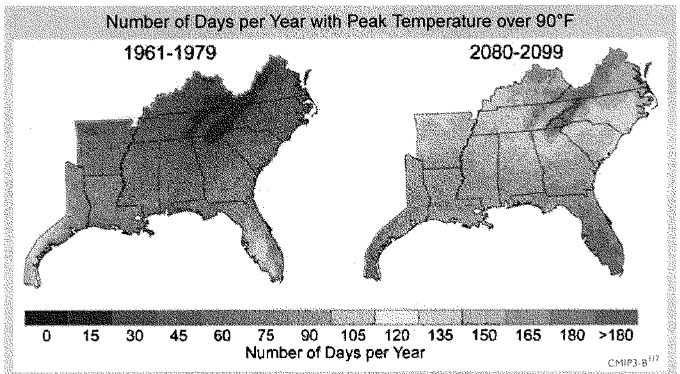
Average autumn precipitation has increased by 30 percent for the region since 1901. The decline in fall precipitation in South Florida contrasts strongly with the regional average. There has been an increase in heavy downpours in many parts of the region,[380,381] while the percentage of the region experiencing moderate to severe drought increased over the past three decades. The area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively, since the mid-1970s. Even in the fall months, when precipitation tended to increase in most of the region, the extent of drought increased by 9 percent.

Climate models project continued warming in all seasons across the Southeast and an increase in the rate of warming through the end of this century. The projected rates of warming are more than double those experienced in the Southeast since 1975, with the greatest temperature increases projected to occur in the summer months. The number of very hot days is projected to rise at a greater rate than the average temperature. Under a lower emissions scenario,[91] average temperatures in the region are projected to rise by about 4.5°F by the 2080s, while a higher emissions scenario[91] yields about 9°F of average warming (with about a 10.5°F increase in summer, and a much higher heat index). Spring and summer rainfall is projected to decline in South Florida during this century. Except for indications that the amount of rainfall from individual hurricanes will increase,[68] climate models provide divergent

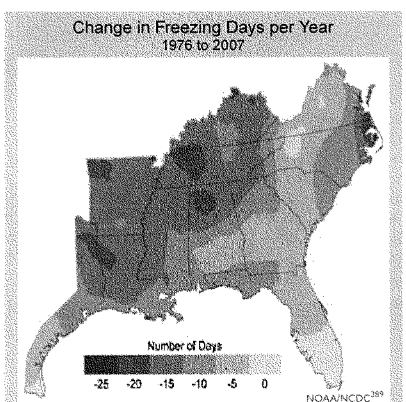
Average Change in Temperature and Precipitation in the Southeast

	Temperature Change in °F			Precipitation change in %	
	1901-2008	1970-2008		1901-2008	1970-2008
Annual	0.3	1.6	Annual	5.8	-7.7
Winter	0.2	2.7	Winter	1.2	-9.6
Spring	0.4	1.2	Spring	1.7	-29.2
Summer	0.4	1.6	Summer	-4.0	3.6
Fall	0.2	1.1	Fall	27.4	0.1

Observed temperature and precipitation changes in the Southeast are summarized above for two different periods.[383] Southeast average temperature declined from 1901 to 1970 and then increased strongly since 1970.



The number of days per year with peak temperature over 90°F is expected to rise significantly, especially under a higher emissions scenario[91] as shown in the map above. By the end of the century, projections indicate that North Florida will have more than 165 days (nearly six months) per year over 90°F, up from roughly 60 days in the 1960s and 1970s. The increase in very hot days will have consequences for human health, drought, and wildfires.



Since the mid-1970s, the number of days per year in which the temperature falls below freezing has declined by four to seven days over much of the Southeast. Some areas, such as western Louisiana, have experienced more than 20 fewer freezing days. Climate models project continued warming across the region, with the greatest increases in temperature expected in summer, and the number of very hot days increasing at a greater rate than the average temperature.

results for future precipitation for the remainder of the Southeast. Models project that Gulf Coast states will tend to have less rainfall in winter and spring, compared with the more northern states in the region (see map on page 31 in the *National Climate Change* section). Because higher temperatures lead to more evaporation of moisture from soils and water loss from plants, the frequency, duration, and intensity of droughts are likely to continue to increase.

The destructive potential of Atlantic hurricanes has increased since 1970, correlated with an increase in sea surface temperature. A similar relationship with the frequency of landfalling hurricanes has not been established[98,384-387] (see *National Climate Change* section for a discussion of past trends and future projections). An increase in average summer wave heights along the U.S. Atlantic coastline since 1975 has been attributed to a progressive increase in hurricane power.[112,388] The intensity of Atlantic hurricanes is likely to increase during this century with higher peak wind speeds, rainfall intensity, and storm surge height and strength.[90,112] Even with no increase in hurricane intensity, coastal inundation and shoreline retreat would increase as sea-level rise accelerates, which is one of the most certain and most costly consequences of a warming climate.[164]

Projected increases in air and water temperatures will cause heat-related stresses for people, plants, and animals.

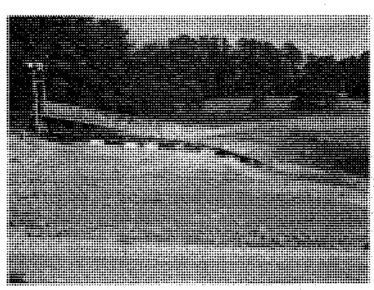
The warming projected for the Southeast during the next 50 to 100 years will create heat-related stress for people, agricultural crops, livestock, trees, transportation and other infrastructure, fish, and wildlife. The average temperature change is not as important for all of these sectors and natural systems as the projected increase in maximum and minimum temperatures. Examples of potential impacts include:

- Increased illness and death due to greater summer heat stress, unless effective adaptation measures are implemented.[164]
- Decline in forest growth and agricultural crop production due to the combined effects of thermal stress and declining soil moisture.[390]
- Increased buckling of pavement and railways.[217,222]
- Decline in dissolved oxygen in stream, lakes, and shallow aquatic habitats leading to fish kills and loss of aquatic species diversity.
- Decline in production of cattle and other rangeland livestock.[391] Significant impacts on beef cattle occur at continuous temperatures in the 90 to 100°F range, increasing in danger as the humidity level increases (see *Agriculture* sector).[391] Poultry and swine are primarily raised in indoor operations, so warming would increase energy requirements.[193]

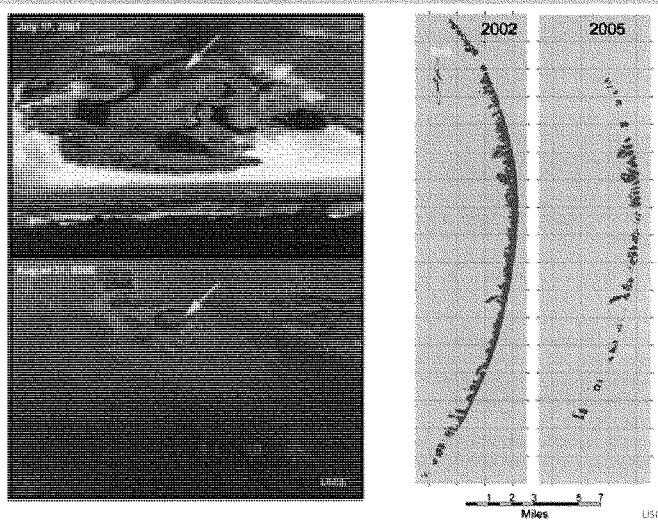
A reduction in very cold days is likely to reduce the loss of human life due to cold-related stress, while heat stress and related deaths in the summer months are likely to increase. The reduction in cold-related deaths is not expected to offset the increase in heat-related deaths (see *Human Health* sector). Other effects of the projected increases in temperature include more frequent outbreaks of shellfish-borne diseases in coastal waters, altered distribution of native plants and animals, local loss of many threatened and endangered species, displacement of native species by invasive species, and more frequent and intense wildfires.

Decreased water availability is very likely to affect the region's economy as well as its natural systems.

Decreased water availability due to increased temperature and longer periods of time between rainfall events, coupled with an increase in societal demand is very likely to affect many sectors of the Southeast's economy. The amount and timing of water available to natural systems is also affected by climate change, as well as by human response strategies such as increasing storage capacity (dams)[142] and increasing acreage of irrigated cropland.[392] The 2007 water shortage in the Atlanta region created serious conflicts between three states, the U.S. Army Corps of Engineers (which operates the dam at Lake Lanier), and the U.S. Fish and Wildlife Service, which is charged with protecting endangered species. As humans seek to adapt to climate change by manipulating water resources, streamflow and biological diversity are likely to be reduced.[142] During droughts, recharge of groundwater will decline as the temperature and spacing between rainfall events increase. Responding by increasing groundwater pumping will further stress or deplete aquifers and place increasing strain on surface water resources. Increasing evaporation and plant water loss rates alter the balance of runoff and groundwater recharge, which is likely to lead to saltwater intrusion into shallow aquifers in many parts of the Southeast.[142]



In Atlanta and Athens, Georgia, 2007 was the second driest year on record. Among the numerous effects of the rainfall shortage were restrictions on water use in some cities and low water levels in area lakes. In the photo, a dock lies on dry land near Aqualand Marina on Lake Lanier (located northeast of Atlanta) in December 2007.



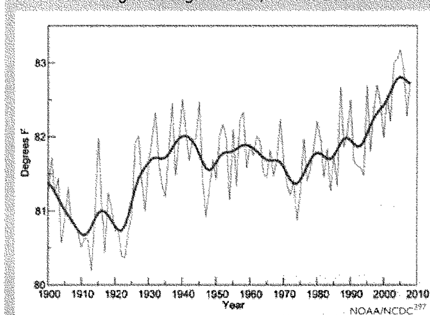
In 2005, 217 square miles of land and wetlands were lost to open water during hurricanes Rita and Katrina. The photos and maps show the Chandeleur Islands, east of New Orleans, before and after the 2005 hurricanes; 85 percent of the islands' above-water land mass was eliminated.

Sea-level rise and the likely increase in hurricane intensity and associated storm surge will be among the most serious consequences of climate change.

An increase in average sea level of up to 2 feet or more and the likelihood of increased hurricane intensity and associated storm surge are likely to be among the most costly consequences of climate change for this region (see *National Climate Change* section). As sea level rises, coastal shorelines will retreat. Wetlands will be inundated and eroded away, and low-lying areas including some communities will be inundated more frequently – some permanently – by the advancing sea. Current buildings and infrastructure were not designed to withstand the intensity of the projected storm surge, which would cause catastrophic damage. As temperature increases and rainfall patterns change, soil moisture and runoff to the coast are likely to be more variable. The salinity of estuaries, coastal wetlands, and tidal rivers is likely to increase in the southeastern coastal zone, thereby altering coastal ecosystems and displacing them farther inland if no barriers exist. More frequent storm surge flooding and permanent inundation of coastal ecosystems and communities is likely in some low-lying areas, particularly along the central Gulf Coast where the land surface is sinking.[393,394] Rapid acceleration in the rate of increase in sea-level rise could threaten a large portion of the Southeast coastal zone. The likelihood of a catastrophic increase in the rate of sea-level rise is dependent upon ice sheet response to warming, which is the subject of much scientific uncertainty (see *Global Climate Change* section).[90] Such rapid rise in sea level is likely to result in the destruction of barrier islands and wetlands.[257,390]

Compared to the present coastal situation, for which vulnerability is quite high, an increase in hurricane intensity will further affect low-lying coastal ecosystems and coastal communities along the Gulf and South Atlantic coastal margin. An increase in intensity is very likely to increase inland and coastal flooding, coastal erosion rates, wind damage to coastal forests, and wetland loss. Major hurricanes also pose a severe risk to people, personal property, and public infrastructure in the Southeast, and this risk is likely to be exacerbated.[393,394] Hurricanes have their greatest impact at the coastal margin where they make landfall, causing storm surge, severe beach erosion, inland flooding, and wind-related casualties for both cultural and natural resources. Some of these impacts extend farther inland, affecting larger areas. Recent examples of societal vulnerability to severe hurricanes include Katrina and Rita in 2005, which were responsible for the loss of more than 1,800 lives and the net loss of 217 square miles of low-lying coastal marshes and barrier islands in southern Louisiana.[390,396]

Sea Surface Temperature
Atlantic Hurricane Main Development Region
August through October, 1900 to 2008

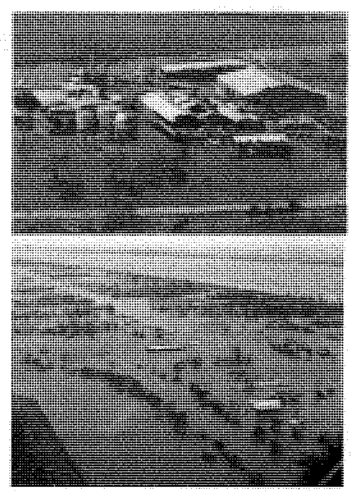


Ocean surface temperature during the peak hurricane season, August through October, in the main development region for Atlantic hurricanes.[397] Higher sea surface temperatures in this region of the ocean have been associated with more intense hurricanes. As ocean temperatures continue to increase in the future, it is likely that hurricane rainfall and wind speeds will increase in response to human-caused warming (see *National Climate Change* section).[68]

Ecological thresholds are expected to be crossed throughout the region, causing major disruptions to ecosystems and to the benefits they provide to people.

Ecological systems provide numerous important services that have high economic and cultural value in the Southeast. Ecological effects cascade among both living and physical systems, as illustrated in the following examples of ecological disturbances that result in abrupt responses, as opposed to gradual and proportional responses to warming:

- The sudden loss of coastal landforms that serve as a storm-surge barrier for natural resources and as a homeland for coastal communities (such as in a major hurricane).[254,390]
- An increase in sea level can have no apparent effect until an elevation is reached that allows widespread, rapid saltwater intrusion into coastal forests and freshwater aquifers.[398]
- Lower soil moisture and higher temperatures leading to intense wildfires or pest outbreaks (such as the southern pine beetle) in southeastern forests;[399] intense droughts leading to the drying of lakes, ponds, and wetlands; and the local or global extinction of riparian and aquatic species.[142]



Flooding damage in Louisiana due to Hurricane Katrina

- A precipitous decline of wetland-dependent coastal fish and shellfish populations due to the rapid loss of coastal marsh.[400]

Quality of life will be affected by increasing heat stress, water scarcity, severe weather events, and reduced availability of insurance for at-risk properties.

Over the past century, the southeastern "sunbelt" has attracted people, industry, and investment. The population of Florida more than doubled during the past three decades, and growth rates in most other southeastern states were in the range of 45 to 75 percent (see population map, page 55). Future population growth and the quality of life for existing residents is likely to be affected by the many challenges associated with climate change, such as reduced insurance availability, increased insurance cost, and increases in water scarcity, sea-level rise, extreme weather events, and heat stress. Some of these problems, such as increasing heat and declining air quality, will be especially acute in cities.

Adaptation: Reducing Exposure to Flooding and Storm Surge

Three different types of adaptation to sea-level rise are available for low-lying coastal areas.[illegible] One is to move buildings and infrastructure farther inland to get out of the way of the rising sea. Another is to accommodate rising water through changes in building design and construction, such as elevating buildings on stilts. Flood insurance programs even require this in some areas with high probabilities of floods. The third adaptation option is to try to protect existing development by building levees and river flood control structures. This option is being pursued in some highly vulnerable areas of the Gulf and South Atlantic coasts. Flood control structures can be designed to be effective in the face of higher sea level and storm surge. Some hurricane levees and floodwalls were not just replaced after Hurricane Katrina, they were redesigned to withstand higher storm surge and wave action.[illegible]

Recent upgrades that raised the height of the earthen levee increased protection against storm surge in the New Orleans area.

The costs and environmental impacts of building such structures can be significant. Furthermore, building levees can actually increase future risks.[illegible] This is sometimes referred to as the levee effect or the safe-development paradox. Levees that provide protection from, for example, the storm surge from a Category 3 hurricane, increase real and perceived safety and thereby lead to increased development. This increased development means there will be greater damage if and when the storm surge from a Category 5 hurricane tops the levee than there would have been if no levee had been constructed.[illegible]

In addition to levees, enhancement of key highways used as hurricane evacuation routes and improved hurricane evacuation planning is a common adaptation underway in all Gulf Coast states.[illegible] Other protection options that are being practiced along low-lying coasts include the enforcement and protection of natural features such as forested wetlands, saltmarshes, and barrier islands.[illegible]

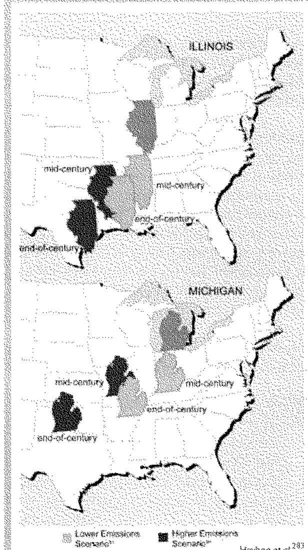
Midwest

The Midwest's climate is shaped by the presence of the Great Lakes and the region's location in the middle of the North American continent. This location, far from the temperature-moderating effects of the oceans, contributes to large seasonal swings in air temperature from hot, humid summers to cold winters. In recent decades, a noticeable increase in average temperatures in the Midwest has been observed, despite the strong year-to-year variations. The largest increase has been measured in winter, extending the length of the frost-free or growing season by more than one week, mainly due to earlier dates for the last spring frost. Heavy downpours are now twice as frequent as they were a century ago. Both summer and winter precipitation have been above average for the last three decades, the wettest period in a century. The Midwest has experienced two record-breaking floods in the past 15 years.[213] There has also been a decrease in lake ice, including on the Great Lakes. Since the 1980s, large heat waves have been more frequent in the Midwest than any time in the last century, other than the Dust Bowl years of the 1930s.[112,283,402-404]

During the summer, public health and quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and insect and waterborne diseases. In the winter, warming will have mixed impacts.

Heat waves that are more frequent, more severe, and longer lasting are projected. The frequency of hot days and the length of the heat-wave season both will be more than twice as great under the higher emissions scenario[91] compared to the lower emissions scenario.[91,283,402,403,405] Events such as the Chicago heat wave of 1995, which resulted in over 700 deaths, will become more common. Under the lower emissions scenario,[91] such a heat wave is projected to occur every other year in Chicago by the end of the century, while under the higher emissions scenario,[91] there would be about three such heat waves per year. Even more severe heat waves, such as the one that claimed tens of thousands of lives in Europe in 2003, are projected to become more frequent in a warmer world, occurring as often as every other year in the Midwest by the end of this century under the higher emissions scenario.[91,283,403,406] Some health impacts can be reduced by better preparation for such events.[288]

Climate on the Move:
Changing Summers in the Midwest



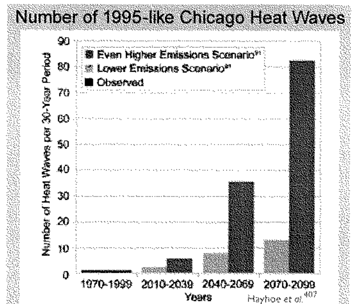
Model projections of summer average temperature and precipitation changes in Illinois and Michigan for mid-century (2040-2059), and end-of-century (2080-2099), indicate that summers in these states are expected to feel progressively more like summers currently experienced in states south and west. Both states are projected to get considerably warmer and have less summer precipitation.

During heat waves, high electricity demand combines with climate-related limitations on energy production capabilities (see *Energy Supply and Use* sector), increasing the likelihood of electricity shortages and resulting in brownouts or even blackouts. This combination can leave people without air conditioning and ventilation when they need it most, as occurred during the 1995 Chicago/Milwaukee heat wave. In general, electricity demand for air conditioning is projected to significantly increase in summer. Improved energy planning could reduce electricity disruptions.

The urban heat island effect can further add to high local daytime and nighttime temperatures (see *Human Health* sector). Heat waves take a greater toll in illness and death when there is little relief from the heat at night.

Another health-related issue arises from the fact that climate change can affect air quality. A warmer climate generally means more ground-level ozone (a component of smog), which can cause respiratory problems, especially for those who are young, old, or have asthma or allergies. Unless the emissions of pollutants that lead to ozone formation are reduced significantly, there will be more ground-level ozone as a result of the projected climate changes in the Midwest due to increased air temperatures, more stagnant air, and increased emissions from vegetation.[283,291,402,403,408-410]

Number of 1995-like Chicago Heat Waves

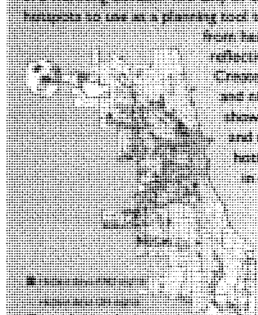


Over the last three decades of this century, heat waves like the one that occurred in Chicago in 1995 are projected to occur about once every three years under the lower emissions scenario.[91] Under the even higher emissions scenario, such events are projected to occur an average of nearly three times a year. In this analysis, heat waves were defined as at least one week of daily maximum temperatures greater than 90°F and nighttime minimum temperatures greater than 70°F, with at least two consecutive days with daily temperatures greater than 100°F and nighttime temperatures greater than 80°F.

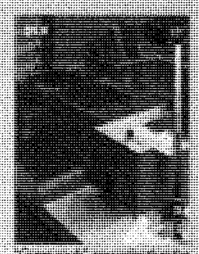
Insects such as ticks and mosquitoes that carry diseases will survive winters more easily and produce larger populations in a warmer Midwest.[283,402,403] One potential risk is an increasing incidence of diseases such as West Nile

Adaptation: Chicago Tries to Cool the Urban Heat Island

Efforts to reduce urban heat island effects become even more important in a warming climate. The City of Chicago has produced a map of urban hotspots to use as a planning tool to target areas that could most benefit from heat-island reduction initiatives such as reflective or green roofing, and tree planting. Created using satellite images of daytime and nighttime temperatures, the map shows the hottest 10 percent of both day and night temperatures in red, and the hottest 10 percent of either day or night in orange.



Chicago's urban hot spots



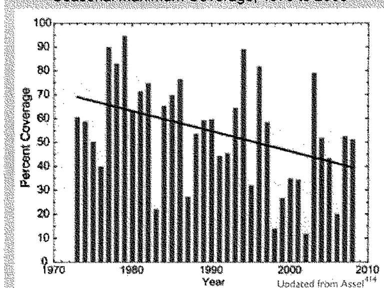
"Green roofs" are cooler than the surrounding conventional roofs.

The City is working to reduce urban heat buildup and the need for air conditioning by using reflective roofing materials. This thermal image shows that the radiating temperature of the City Hall's "green roof" – covered with soil and vegetation – is up to 77°F cooler than the nearby conventional roofs.

virus. Waterborne diseases will present an increasing risk to public health because many pathogens thrive in warmer conditions.[163]

In winter, oil and gas demand for heating will decline. Warming will also decrease the number of days with snow on the ground, which is expected to improve traffic safety.[222] On the other hand, warming will decrease outdoor winter recreational opportunities such as skiing, snowmobiling, ice skating, and ice fishing.

Observed Changes in Great Lakes Ice Cover
Seasonal Maximum Coverage, 1973 to 2008

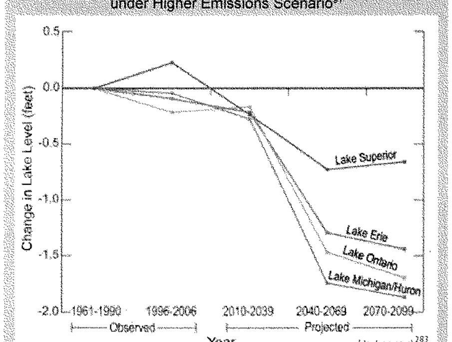


Reductions in winter ice cover lead to more evaporation, causing lake levels to drop even farther. While the graph indicates large year-to-year variations, there is a clear decrease in the extent of Great Lakes ice coverage, as shown by the black trend line.

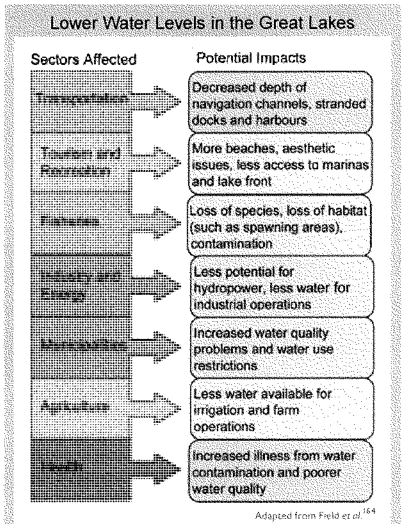
Significant reductions in Great Lakes water levels, which are projected under higher emissions scenarios, lead to impacts on shipping, infrastructure, beaches, and ecosystems.

The Great Lakes are a natural resource of tremendous significance, containing 20 percent of the planet's fresh surface water and serving as the dominant feature of the industrial heartland of the nation. Higher temperatures will mean more evaporation and hence a likely reduction in the Great Lakes water levels. Reduced lake ice increases evaporation in winter, contributing to the decline. Under a lower emissions scenario,[91] water levels in the Great Lakes are projected to fall no more than 1 foot by the end of the century, but under a higher emissions scenario,[91] they are projected to fall between 1 and 2 feet.[283] The greater the temperature rise, the higher the likelihood of a larger decrease in lake levels.[412] Even a decrease of 1 foot, combined with normal fluctuations, can result in significant lengthening of the distance to the lakeshore in many places. There are also potential impacts on beaches, coastal ecosystems, dredging requirements, infrastructure, and shipping. For example, lower lake levels reduce "draft," or the distance between the waterline and the bottom of a ship, which lessens a ship's ability to carry freight. Large vessels, sized for passage through the St. Lawrence Seaway, lose up to 240 tons of capacity for each inch of draft lost.[283,402,403,413] These impacts will have costs, including increased shipping, repair and maintenance costs, and lost recreation and tourism dollars.

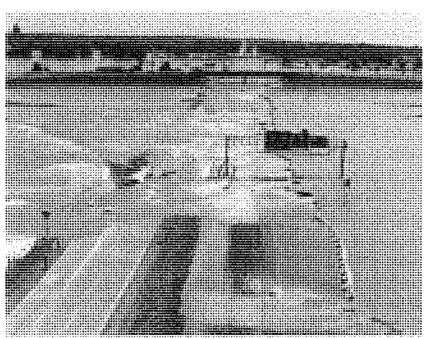
Projected Changes in Great Lakes Levels
under Higher Emissions Scenario[91]



Average Great Lakes levels depend on the balance between precipitation (and corresponding runoff) in the Great Lakes Basin on one hand, and evaporation and outflow on the other. As a result, lower emissions scenarios[91] with less warming show less reduction in lake levels than higher emissions scenarios.[91] Projected changes in lake levels are based on simulations by the NOAA Great Lakes model for projected climate changes under a higher emissions scenario.[91]



Reduced water levels in the Great Lakes will have interconnected impacts across many sectors, creating mismatches between water supply and demand, and necessitating trade-offs. Regions outside the Midwest will also be affected. For example, a reduction in hydropower potential would affect the Northeast, and a reduction in irrigation water would affect regions that depend on agricultural produce from the Midwest.



The Great Flood of 1993 caused flooding along 500 miles of the Mississippi and Missouri river systems. The photo shows the flood's effects on U.S. Highway 54, just north of Jefferson City, Missouri.

The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer would lead to more periods of both floods and water deficits.

Precipitation is projected to increase in winter and spring, and to become more intense throughout the year. This pattern is expected to lead to more frequent flooding, increasing infrastructure damage, and impacts on human health. Such heavy downpours can overload drainage systems and water treatment facilities, increasing the risk of waterborne diseases. Such an incident occurred in Milwaukee in 1993 when the water supply was contaminated with the parasite *Cryptosporidium*, causing 403,000 reported cases of gastrointestinal illness and 54 deaths.[219]

In Chicago, rainfall of more than 2.5 inches per day is an approximate threshold beyond which combined water and sewer systems overflow into Lake Michigan (such events occurred 2.5 times per decade from 1961 to 1990). This generally results in beach closures to reduce the risk of disease transmission. Rainfall above this threshold is projected to occur twice as often by the end of this century under the lower emissions scenario[91] and three times as often under the higher emissions scenario.[91,283,403] Similar increases are expected across the Midwest.

More intense rainfall can lead to floods that cause significant impacts regionally and even nationally. For example, the Great Flood of 1993 caused catastrophic flooding along 500 miles of the Mississippi and Missouri river systems, affecting one-quarter of all U.S. freight (see *Transportation* sector).[222,415-417] Another example was a record-breaking 24-hour rainstorm in July 1996, which resulted in flash flooding in Chicago and its suburbs, causing extensive damage and disruptions, with some commuters not being able to reach Chicago for three days (see *Transportation* sector).[222] There was also a record-breaking storm in August 2007. Increases in such events are likely to cause greater property damage, higher insurance rates, a heavier burden on emergency management, increased clean-up and rebuilding costs, and a growing financial toll on businesses, homeowners, and insurers.

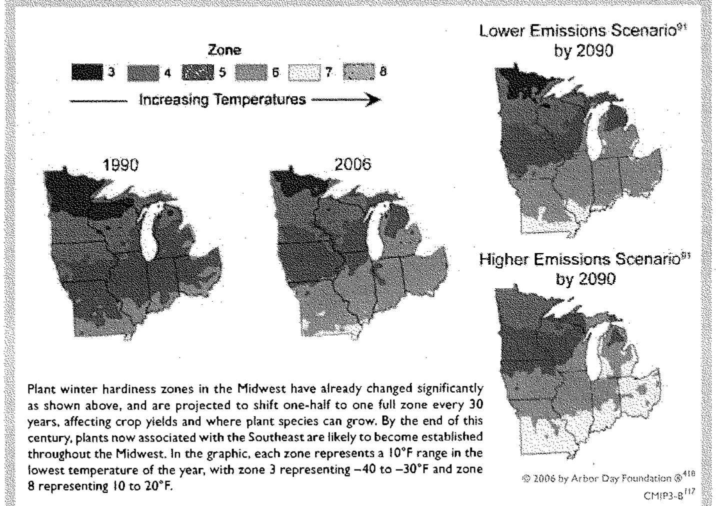
In the summer, with increasing evaporation rates and longer periods between rainfalls, the likelihood of drought will increase and water levels in rivers, streams, and wetlands are likely to decline. Lower water levels also could create problems for river traffic, reminiscent of the stranding of more than 4,000 barges on the Mississippi River during the 1988 drought. Reduced summer water levels are also likely to reduce the recharge of groundwater, cause small streams to dry up (reducing native fish populations), and reduce the area of wetlands in the Midwest.

While the longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests.

The projected increase in winter and spring precipitation and flooding is likely to delay planting and crop establishment. Longer growing seasons and increased carbon dioxide have positive effects on some crop yields, but this is likely to be counterbalanced in part by the negative effects of additional disease-causing pathogens, insect pests, and weeds (including invasive weeds).[193] Livestock production is expected to become more costly as higher temperatures stress livestock, decreasing productivity and increasing costs associated with the needed ventilation and cooling equipment.[193]

Plant winter hardiness zones (each zone represents a 10°F change in minimum temperature) in the Midwest are likely to shift one-half to one full zone

Observed and Projected Changes in Plant Hardiness Zones



Plant winter hardiness zones in the Midwest have already changed significantly as shown above, and are projected to shift one-half to one full zone every 30 years, affecting crop yields and where plant species can grow. By the end of this century, plants now associated with the Southeast are likely to become established throughout the Midwest. In the graphic, each zone represents a 10°F range in the lowest temperature of the year, with zone 3 representing −40 to −30°F and zone 8 representing 10 to 20°F.

about every 30 years. By the end of the century, plants now associated with the Southeast are likely to become established throughout the Midwest.

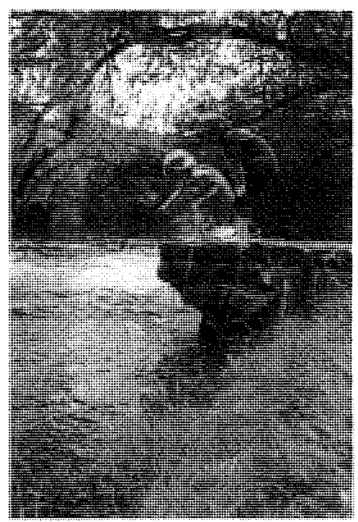
Impacts on forests are likely to be mixed, with the positive effects of higher carbon dioxide and nitrogen levels acting as fertilizers potentially negated by the negative effects of decreasing air quality.[243] In addition, more frequent droughts, and hence fire hazards, and an increase in destructive insect pests, such as gypsy moths, hinder plant growth. Insects, historically controlled by cold winters, more easily survive milder winters and produce larger populations in a warmer climate (see *Agriculture* and *Ecosystems* sectors).

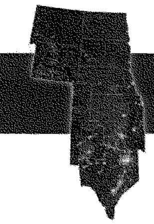
Native species are very likely to face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species moving in from warmer regions.

As air temperatures increase, so will water temperatures. In some lakes, this will lead to an earlier and longer period in summer during which mixing of the relatively warm surface lake water with the colder water below is reduced.[564] In such cases, this stratification can cut off oxygen from bottom layers, increasing the risk of oxygen-poor or oxygen-free "dead zones" that kill fish and other living things. In lakes with contaminated sediment, warmer water and low-oxygen conditions can more readily mobilize mercury and other persistent pollutants.[565] In such cases, where these increasing quantities of contaminants are taken up in the aquatic food chain, there will be additional potential for health hazards for species that eat fish from the lakes, including people.[566]

Populations of coldwater fish, such as brook trout, lake trout, and whitefish, are expected to decline dramatically, while populations of coolwater fish such as muskie, and warmwater species such as smallmouth bass and bluegill, will take their place. Aquatic ecosystem disruptions are likely to be compounded by invasions by non-native species, which tend to thrive under a wide range of environmental conditions. Native species, adapted to a narrower range of conditions, are expected to decline.

All major groups of animals, including birds, mammals, amphibians, reptiles, and insects, will be affected by impacts on local populations, and by competition from other species moving into the Midwest region.[70] The potential for animals to shift their ranges to keep pace with the changing climate will be inhibited by major urban areas and the presence of the Great Lakes.



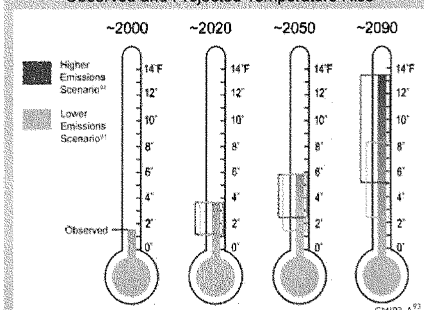


Great Plains

The Great Plains is characterized by strong seasonal climate variations. Over thousands of years, records preserved in tree rings, sediments, and sand deposits provide evidence of recurring periods of extended drought (such as the Dust Bowl of the 1930s) alternating with wetter conditions.[97,419]

Today, semi-arid conditions in the western Great Plains gradually transition to a moister climate in the eastern parts of the region. To the north, winter days in North Dakota average 25°F, while it is not unusual to have a West Texas winter day over 75°F. In West Texas, there are between 70 and 100 days per year over 90°F, whereas North Dakota has only 10 to 20 such days on average.

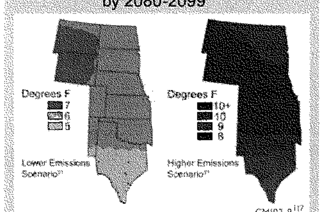
Observed and Projected Temperature Rise



The average temperature in the Great Plains already has increased roughly 1.5°F relative to a 1960s and 1970s baseline. By the end of the century, temperatures are projected to continue to increase by 2.5°F to more than 13°F compared with the 1960 to 1979 baseline, depending on future emissions of heat-trapping gases. The brackets on the thermometers represent the likely range of model projections, though lower or higher outcomes are possible.

Significant trends in regional climate are apparent over the last few decades. Average temperatures have increased throughout the region, with the largest changes occurring in winter months and over the northern states. Relatively cold days are becoming less frequent and relatively hot days more frequent.[420] Precipitation has also increased over most of the area.[149,421]

Summer Temperature Change by 2080-2099



Temperatures in the Great Plains are projected to increase significantly by the end of this century, with the northern part of the region experiencing the greatest projected increase in temperature.

Temperatures are projected to continue to increase over this century, with larger changes expected under scenarios of higher heat-trapping emissions as compared to lower heat-trapping emissions. Summer changes are projected to be larger than those in winter in the southern and central Great Plains.[108] Precipitation is also projected to change, particularly in winter and spring. Conditions are anticipated to become wetter in the north and drier in the south.

Projected changes in long-term climate and more frequent extreme events such as heat waves, droughts, and heavy rainfall will affect many aspects of life in the Great Plains. These include the region's already threatened water resources, essential agricultural and ranching activities, unique natural and protected areas, and the health and prosperity of its inhabitants.

Projected increases in temperature, evaporation, and drought frequency add to concerns about the region's declining water resources.

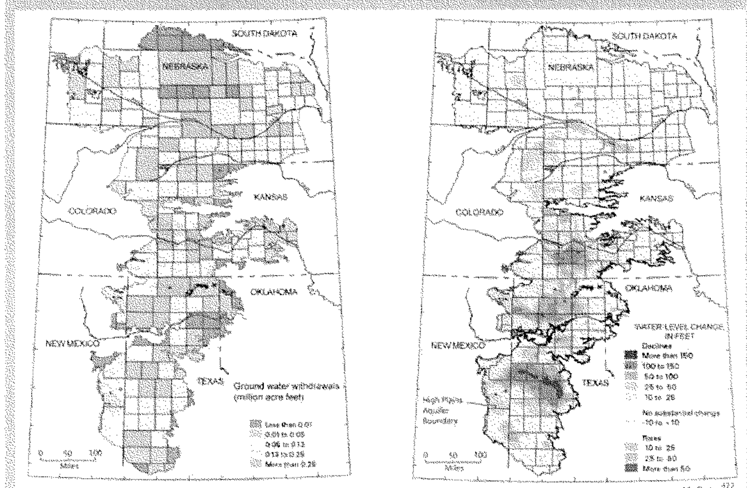
Water is the most important factor affecting activities on the Great Plains. Most of the water used in the Great Plains comes from the High Plains aquifer (sometimes referred to by the name of its largest formation, the Ogallala aquifer), which stretches from South Dakota to Texas. The aquifer holds both current recharge from precipitation and so-called "ancient" water, water trapped by silt and soil washed down from the Rocky Mountains during the last ice age.

As population increased in the Great Plains and irrigation became widespread, annual water withdrawals began to outpace natural recharge.[422]

Today, an average of 19 billion gallons of groundwater are pumped from the aquifer each day. This water irrigates 13 million acres of land and provides drinking water to over 80 percent of the region's population.[423] Since 1950, aquifer water levels have dropped an average of 13 feet, equivalent to a 9 percent decrease in aquifer storage. In heavily irrigated parts of Texas, Oklahoma, and Kansas, reductions are much larger, from 100 feet to over 250 feet.

Projections of increasing temperatures, faster evaporation rates, and more sustained droughts brought on by climate change will only add more stress to overtaxed water sources.[149,253,424,425] Current water use on the Great Plains is unsustainable, as the High Plains aquifer continues to be tapped faster than the rate of recharge.

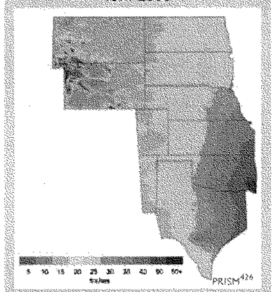
Groundwater Withdrawals for Irrigation 1950 to 2005 **Water Level Changes in the High Plains Aquifer 1950 to 2005**



McGuire[422]

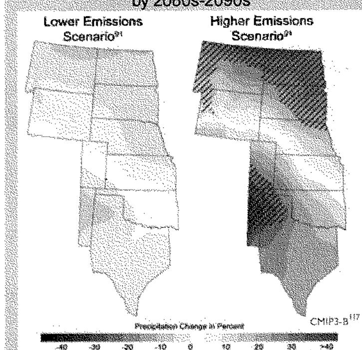
Irrigation is one of the main factors stressing water resources in the Great Plains. In parts of the region, more than 81 trillion gallons of water (pink areas on the left hand map) were withdrawn for irrigation in Texas, Oklahoma, and Kansas from 1950 to 2005. During the same time period, water levels in parts of the High Plains aquifer in those states decreased by more than 150 feet (red areas on the right hand map).

Average Annual Observed Precipitation 1971-2000



The Great Plains currently experiences a sharp precipitation gradient from east to west, from more than 50 inches of precipitation per year in eastern Oklahoma and Texas to less than 10 inches in some of the western parts of the region.

Projected Spring Precipitation Change by 2080s-2090s



Northern areas of the Great Plains are projected to experience a wetter climate by the end of this century, while southern areas are projected to experience a drier climate. The change in precipitation is compared with a 1960-1979 baseline. Confidence in the projected changes is highest in the hatched areas.

The Dust Bowl: Combined Effects of Land Use and Climate

Over the past century, large-scale conversion of grasslands to crops and ranchland has altered the natural environment of the Great Plains.[177] Irrigated fields have increased evaporation rates, reducing summer temperatures, and increasing local precipitation.[427,428]

The Dust Bowl of the 1930s epitomizes what can happen as a result of interactions between climate and human activity. In the 1920s, increasing demand for food encouraged poor agricultural practices. Small-scale producers ploughed under native grasses to plant wheat, removing the protective cover the land required to retain its moisture.

Dust Bowl of 1935 in Stratford, Texas

Variations in ocean temperature contributed to a slight increase in air temperatures, just enough to change the winds that typically draw moisture from the south into the Great Plains. As the intensively tilled soils dried up, topsoil from an estimated 100 million acres of the Great Plains blew across the continent.

The Dust Bowl dramatically demonstrated the potentially devastating effects of poor land-use practices combined with climate variability and change.[429] Today, climate change is interacting with a different set of poor land-use practices. Water is being pumped from the Ogallala aquifer faster than it can recharge. In many areas, playa lakes are poorly managed (see page 127). Existing stresses on water resources in the Great Plains due to unsustainable water usage are likely to be exacerbated by future changes in temperature and precipitation, this time largely due to human-induced climate change.

Agriculture, ranching, and natural lands, already under pressure due to an increasingly limited water supply, are very likely to also be stressed by rising temperatures.

Agricultural, range, and croplands cover more than 70 percent of the Great Plains, producing wheat, hay, corn, barley, cattle, and cotton. Agriculture is fundamentally sensitive to climate. Heat and water stress from droughts and heat waves can decrease yields and wither crops.[430,431] The influence of long-term trends in temperature and precipitation can be just as great.[431]

As temperatures increase over this century, optimal zones for growing particular crops will shift. Pests that were historically unable to survive in the Great Plains' cooler areas are expected to spread northward. Milder winters and earlier springs also will encourage greater numbers and earlier emergence of insects.[149] Rising carbon dioxide levels in the atmosphere can increase crop growth, but also make some types of weeds grow even faster (see *Agriculture* sector).[432]

Projected increases in precipitation are unlikely to be sufficient to offset decreasing soil moisture and water availability in the Great Plains due to rising temperatures and aquifer depletion. In some areas, there is not expected to be enough water for agriculture to sustain even current usage.

With limited water supply comes increased vulnerability of agriculture to climate change. Further stresses on water supply for agriculture and ranching are likely as the region's cities continue to grow, increasing competition between urban and rural users.[433] The largest impacts are expected in heavily irrigated areas in the southern Great Plains, already plagued by unsustainable water use and greater frequency of extreme heat.[149]

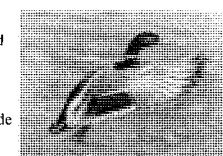
Successful adaptation will require diversification of crops and livestock, as well as transitions from irrigated to rain-fed agriculture.[434-436] Producers who can adapt to changing climate conditions are likely to see their businesses survive; some might even thrive. Others, without resources or ability to adapt effectively, will lose out.

Climate change is likely to affect native plant and animal species by altering key habitats such as the wetland ecosystems known as prairie potholes or playa lakes.

Ten percent of the Great Plains is protected lands, home to unique ecosystems and wildlife. The region is a haven for hunters and anglers, with its ample supplies of wild game such as moose, elk, and deer; birds such as goose, quail, and duck; and fish such as walleye and bass.

Climate-driven changes are likely to combine with other human-induced stresses to further increase the vulnerability of natural ecosystems to pests, invasive species, and loss of native species. Changes in temperature and precipitation affect the composition and diversity of native animals and plants through altering their breeding patterns, water and food supply, and habitat availability.[149] In a changing climate, populations of some pests such as red fire ants and rodents, better adapted to a warmer climate, are projected to increase.[437,438] Grassland and plains birds, already besieged by habitat fragmentation, could experience significant shifts and reductions in their ranges.[439]

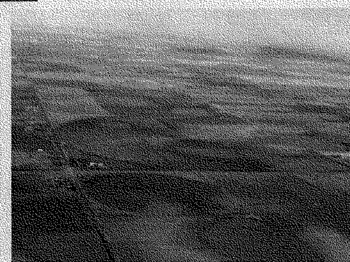
Urban sprawl, agriculture, and ranching practices already threaten the Great Plains' distinctive wetlands. Many of these are home to endangered and iconic species. In particular, prairie wetland ecosystems provide crucial habitat for migratory waterfowl and shorebirds.


Mallard ducks are one of the many species that inhabit the playa lakes, also known as prairie potholes.

Ongoing shifts in the region's population from rural areas to urban centers will interact with a changing climate, resulting in a variety of consequences.

Inhabitants of the Great Plains include a rising number of urban dwellers, a long tradition of rural communities, and extensive Native American

Playa Lakes and Prairie Potholes

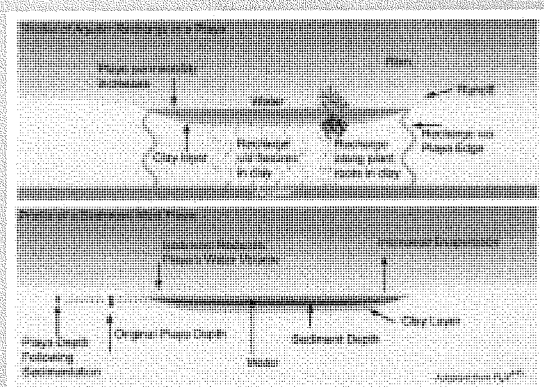


Playa lakes in west Texas fill up after a heavy spring rain.

Shallow ephemeral lakes dot the Great Plains, anomalies of water in the arid landscape. In the north they are known as prairie potholes; in the south, playa lakes. These lakes create unique microclimates that support diverse wildlife and plant communities. A playa can lie with little or no water for long periods, or have several wet/dry cycles each year. When it rains, what appeared to be only a few clumps of short, dry grasses just a few days earlier suddenly teems with frogs, toads, clam shrimp, and aquatic plants.

The playas provide a perfect home for migrating birds to feed, mate, and raise their young. Millions of shorebirds and waterfowl, including Canada geese, mallard ducks, and Sandhill cranes, depend on the playas for their breeding grounds. From the prairie potholes of North Dakota to the playa lakes of West Texas, the abundance and diversity of native bird species directly depends on these lakes.[440,441]

Despite their small size, playa lakes and prairie potholes also play a critical role in supplying water to the Great Plains. The contribution of the playa lakes to this sensitively balanced ecosystem needs to be monitored and maintained in order to avoid unforeseen impacts on our natural resources. Before cultivation, water from these lakes was the primary source of recharge to the High Plains aquifer.[442] But many playas are disappearing and others are threatened by growing urban populations, extensive agriculture, and other filling and tilling practices.[443] In recent years, agricultural demands have drawn down the playas to irrigate crops. Agricultural waste and fertilizer residues drain into playas, decreasing the quality of the water, or clogging them so the water cannot trickle down to refill the aquifer. Climate change is expected to add to these stresses, with increasing temperatures and changing rainfall patterns altering rates of evaporation, recharge, and runoff to the playa lake systems.[444]



populations. Although farming and ranching remain primary uses of the land – taking up much of the region's geographical area – growing cities provide housing and jobs for more than two-thirds of the population. For everyone on the Great Plains, though, a changing climate and a limited water supply are likely to challenge their ability to thrive, leading to conflicting interests in the allocation of increasingly scarce water resources.[313,433]

Native American communities

The Great Plains region is home to 65 Native American tribes. Native populations on rural tribal lands have limited capacities to respond to climate change.[313] Many reservations already face severe problems with water quantity and quality – problems likely to be exacerbated by climate change and other human-induced stresses.

Rural communities

As young adults move out of small, rural communities, the towns are increasingly populated by a vulnerable demographic of very old and very young people, placing them more at risk for health issues than urban communities. Combined effects of changing demographics and climate are likely to make it more difficult to supply adequate and efficient public health services and educational opportunities to rural areas. Climate-driven shifts in optimal crop types and increased risk of drought, pests, and extreme events will add more economic stress and tension to traditional communities.[430,433]

Urban populations

Although the Great Plains is not yet known for large cities, many mid-sized towns throughout the region are growing rapidly. One in four of the most rapidly growing cities in the nation is located in the Great Plains[446] (see *Society* sector). Most of these growing centers can be found in the southern parts of the region, where water resources are already seriously constrained. Urban populations, particularly the young, elderly, and economically disadvantaged, may also be disproportionately affected by heat.[447]

New opportunities

There is growing recognition that the enormous wind power potential of the Great Plains could provide new avenues for future employment and land use. Texas already produces the most wind power of any state. Wind energy production is also prominent in Oklahoma. North and South Dakota have rich wind potential.[191]

As climate change creates new environmental conditions, effective adaptation strategies become increasingly essential to ecological and socioeconomic survival. A great deal of the Great Plains' adaptation potential might be realized through agriculture. For example, plant species that mature earlier and are more resistant to disease and pests are more likely to thrive under warmer conditions.

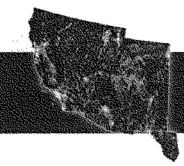
Other emerging adaptation strategies include dynamic cropping systems and increased crop diversity. In particular, mixed cropping-livestock systems maximize available resources while minimizing the need for external inputs such as irrigation that draws down precious water supplies.[436] In many parts of the region, diverse cropping systems and improved water use efficiency will be key to sustaining crop and rangeland systems.[448] Reduced water supplies might cause some farmers to alter the intensive cropping systems currently in use.[193,219]

Adaptation: Agricultural Practices to Reduce Water Loss and Soil Erosion

Conservation of water is critical to efficient crop production in areas where water can be scarce. Following the Dust Bowl in the 1930s, Great Plains farmers implemented a number of improved farming practices to increase the effectiveness of rainfall capture and retention in the soil and protect the soil against water and wind erosion. Examples include rotating crops, retaining crop residues, increasing vegetative cover, and altering plowing techniques.

With observed and projected increases in summer temperatures and in the frequency and intensity of heavy downpours, it will become even more important to protect against increasing loss of water and soil. Across the upper Great Plains, where strong storms are projected to occur more frequently, producers are being encouraged to increase the amount of crop residue left on the soil or to plant cover crops in the fall to protect the soil in the spring before crops are planted.

Across the southern Great Plains, some farmers are returning to dryland farming rather than relying on irrigation for their crops. Preserving crop residue helps the soil absorb more moisture from rain and eases the burden on already-strained groundwater. These efforts have been promoted by the U.S. Department of Agriculture through research and extension efforts such as Kansas State University's Center for Sustainable Agriculture and Alternative Crops.

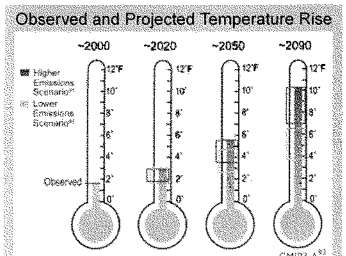


Southwest

The Southwest region stretches from the southern Rocky Mountains to the Pacific Coast. Elevations range from the lowest in the country to among the highest, with climates ranging from the driest to some of the wettest. Past climate records based on changes in Colorado River flows indicate that drought is a frequent feature of the Southwest, with some of the longest documented "megadroughts" on Earth. Since the 1940s, the region has experienced its most rapid population and urban growth. During this time, there were both unusually wet periods (including much of 1980s and 1990s) and dry periods (including much of 1950s and 1960s).[449] The prospect of future droughts becoming more severe as a result of global warming is a significant concern, especially because the Southwest continues to lead the nation in population growth.

Human-induced climate change appears to be well underway in the Southwest. Recent warming is among the most rapid in the nation, significantly more than the global average in some areas. This is driving declines in spring snowpack and Colorado River flow.[34,160,161] Projections suggest continued strong warming, with much larger increases under higher emissions scenarios[91] compared to lower emissions scenarios. Projected summertime temperature increases are greater than the annual average increases in some parts of the region, and are likely to be exacerbated locally by expanding urban heat island effects.[450] Further water cycle changes are projected, which, combined with increasing temperatures, signal a serious water supply challenge in the decades and centuries ahead.[34,159]

Observed and Projected Temperature Rise



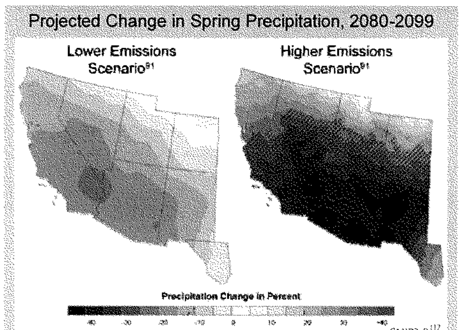
The average temperature in the Southwest has already increased roughly 1.5°F compared to a 1960-1979 baseline period. By the end of the century, average annual temperature is projected to rise approximately 4°F to 10°F above the historical baseline, averaged over the Southwest region. The brackets on the thermometers represent the likely range of model projections, though lower or higher outcomes are possible.

Water supplies are projected to become increasingly scarce, calling for trade-offs among competing uses, and potentially leading to conflict.

Water is, quite literally, the lifeblood of the Southwest. The largest use of water in the region is associated with agriculture, including some of the nation's most important crop-producing areas in California. Water is also an important source of hydroelectric power, and water is required for the large population growth in the region, particularly that of major cities such as Phoenix and Las Vegas. Water also plays a critical role in supporting healthy ecosystems across the region, both on land and in rivers and lakes.

Water supplies in some areas of the Southwest are already becoming limited, and this trend toward scarcity is likely to be a harbinger of future water shortages.[34,451] Groundwater pumping is lowering water tables, while rising temperatures reduce river flows in vital rivers including the Colorado.[34] Limitations imposed on water supply by projected temperature increases are likely to be made worse by substantial reductions in rain and snowfall in the spring months, when precipitation is most needed to fill reservoirs to meet summer demand.[151]

A warmer and drier future means extra care will be needed in planning the allocation of water for the coming decades. The Colorado Compact, negotiated in the 1920s, allocated the Colorado River's water among the seven basin states. It was based, however, on unrealistic assumptions about how much water was available because the observations of runoff during the early 1900s turned out to be part of the greatest and longest high-flow period of the last five centuries.[452] Today, even in normal decades, the Colorado River does not have enough water to meet the agreed-upon allocations. During droughts and under projected future conditions, the situation looks even bleaker.



Percentage change in March-April-May precipitation for 2080-2099 compared to 1961-1979 for a lower emissions scenario[91] (left) and a higher emissions scenario[91] (right). Confidence in the projected changes is highest in the hatched areas.

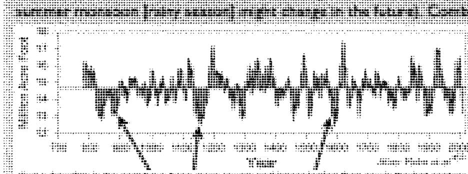
During droughts, water designated for agriculture could provide a temporary back-up supply for urban water needs. Similarly, non-renewable groundwater could be tapped during especially dry periods. Both of these options, however, come at the cost of either current or future agricultural production.

Water is already a subject of contention in the Southwest, and climate change – coupled with rapid population growth – promises to increase the likelihood of water-related

Future of Drought in the Southwest

Droughts are a long-standing feature of the Southwest's climate. The droughts of the last 110 years pale in comparison to some of the decades-long "megadroughts" that the region has experienced over the last 2000 years. During the closing decades of the 1500s, for example, major droughts gripped parts of the Southwest. These droughts sharply reduced the flow of the Colorado River and the all-important Sierra Nevada headwaters for California, and dried out the region as a whole. As of 2009, much of the Southwest remains in a drought that began around 1999. This event is the most severe western drought of the last 110 years, and is being exacerbated by record warming.

Over this century, projections point to an increasing probability of drought for the region. Many aspects of these projections, including a northward shift in winter and spring storm tracks, are consistent with observed trends over recent decades. Thus, the most likely future for the Southwest is a substantially drier one (although there is presently no consensus on how the region's summer monsoon [rainy season] might change in the future). Combined with the historical record of severe droughts and the current uncertainty regarding the exact causes and drivers of these past events, the Southwest must be prepared for droughts that could potentially result from multiple causes. The combined effects of natural climate variability and human-induced climate change could turn out to be a devastating "one-two punch" for the region.



Colorado River flow has been reconstructed back over 1200 years based primarily on tree-ring data. These data reveal that some droughts in the past have been more severe and longer lasting than any experienced in the last 100 years. The red line indicates actual measurements of river flow during the last 100 years. Models indicate that, in the future, droughts will continue to occur, but will become hotter, and thus more severe, over time.

conflict. Projected temperature increases, combined with river-flow reductions, will increase the risk of water conflicts between sectors, states, and even nations. In recent years, negotiations regarding existing water supplies have taken place among the seven states sharing the Colorado River and the two states (New Mexico and Texas) sharing the Rio Grande. Mexico and the United States already disagree on meeting their treaty allocations of Rio Grande and Colorado River water.

In addition, many water settlements between the U.S. Government and Native American tribes have yet to be fully worked out. The Southwest is home to dozens of Native communities whose status as sovereign nations means they hold rights to the water for use on their land. However, the amount of water actually available to each nation is determined through negotiations and litigation. Increasing water demand in the Southwest is driving current negotiations and litigation of tribal water rights. While several nations have legally settled their water rights, many other tribal negotiations are either currently underway or pending. Competing demands from treaty rights, rapid development, and changes in agriculture in the region, exacerbated by years of drought and climate change, have the potential to spark significant conflict over an already over-allocated and dwindling resource.

Increasing temperature, drought, wildfire, and invasive species will accelerate transformation of the landscape.

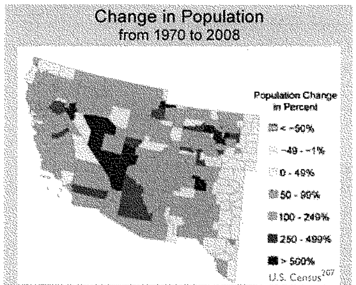
Climate change already appears to be influencing both natural and managed ecosystems of the Southwest.[455,458] Future landscape impacts are likely to be substantial, threatening biodiversity, protected areas, and ranching and agricultural lands. These changes are often driven by multiple factors, including changes in temperature and drought patterns, wildfire, invasive species, and pests.

Conditions observed in recent years can serve as indicators for future change. For example, temperature increases have made the current drought in the region more severe than the natural droughts of the last several centuries. As a result, about 4,600 square miles of piñon-juniper woodland in the Four Corners region of the Southwest have experienced substantial die-off of piñon pine trees.[455] Record wildfires are also being driven by rising temperatures and related reductions in spring snowpack and soil moisture.[458]

How climate change will affect fire in the Southwest varies according to location. In general, total area burned is projected to increase.[459] How this plays out at individual locations, however, depends on regional changes in temperature and precipitation, as well as on whether fire in the area is currently limited by fuel availability or by rainfall.[460] For example, fires in wetter, forested areas are expected to increase in frequency, while areas where fire is limited by the availability of fine fuels experience decreases.[460] Climate changes could also create subtle shifts in fire behavior, allowing more "runaway fires" – fires that are thought to have been brought under control, but then rekindle.[461] The magnitude of fire damages, in terms of economic impacts as well as direct endangerment, also increases as urban development increasingly impinges on forested areas.[460,462]

Climate-fire dynamics will also be affected by changes in the distribution of ecosystems across the Southwest. Increasing temperatures and shifting precipitation patterns will drive declines in high-elevation ecosystems such as alpine forests and tundra.[459,463] Under higher emissions scenarios,[91] high-elevation forests in California, for example, are projected to decline by 60 to 90 percent before the end of the century.[284,459] At the same time, grasslands are projected to expand, another factor likely to increase fire risk.

As temperatures rise, some iconic landscapes of the Southwest will be greatly altered as species shift their ranges northward and upward to cooler climates, and fires attack unaccustomed ecosystems which lack natural defenses. The Sonoran Desert, for example, famous for the saguaro cactus, would look very different if more woody species spread northward from Mexico into areas currently dominated by succulents (such as cacti) or native grasses.[464] The desert is already being invaded by red brome and buffle grasses that do well in high temperatures and are native to Africa and the



The map above of percentage changes in county population between 1970 and 2008 shows that the Southwest has experienced very rapid growth in recent decades (indicated in orange, red, and maroon).

Mediterranean. Not only do these noxious weeds out-compete some native species in the Sonoran Desert, they also fuel hot, cactus-killing fires. With these invasive plant species and climate change, the Saguaro and Joshua Tree national parks could end up with far fewer of their namesake plants.[465] In California, two-thirds of the more than 5,500 native plant species are projected to experience range reductions up to 80 percent before the end of this century under projected warming.[466] In their search for optimal conditions, some species will move uphill, others northward, breaking up present-day ecosystems; those species moving southward to higher elevations might cut off future migration options as temperatures continue to increase.

The potential for successful plant and animal adaptation to coming change is further hampered by existing regional threats such as human-caused fragmentation of the landscape, invasive species, river-flow reductions, and pollution. Given the mountainous nature of the Southwest, and the associated impediments to species shifting their ranges, climate change likely places other species at risk. Some areas have already been identified as possible refuges where species at risk could continue to live if these areas were preserved for this purpose.[466] Other rapidly changing landscapes will require major adjustments, not only from plant and animal species, but also by the region's ranchers, foresters, and other inhabitants.

Increased frequency and altered timing of flooding will increase risks to people, ecosystems, and infrastructure.

Paradoxically, a warmer atmosphere and an intensified water cycle are likely to mean not only a greater likelihood of drought for the Southwest, but also an increased risk of flooding. Winter precipitation in Arizona, for example, is already

A Biodiversity Hotspot

The Southwest is home to two of the world's 34 designated "biodiversity hotspots." These at-risk regions have two special qualities: they hold unusually large numbers of plant and animal species that are endemic (found nowhere else), and they have already lost over 70 percent of their native vegetation.[illegible] About half the world's species of plants and land animals occur only in these 34 locations, though they cover just 2.3 percent of the Earth's land surface.

One of these biodiversity hotspots is the Madrean Pine-Oak Woodlands. Once covering 178 square miles, only isolated patches remain in the United States, mainly on mountaintops in southern Arizona, New Mexico, and West Texas. The greatest diversity of pine species in the world grows in this area: 44 of the 110 varieties,[illegible] as well as more than 150 species of oak.[illegible] Some 5,300 to 6,700 flowering plant species inhabit the ecosystem, and over 500 bird species, 23 of which are endemic. More hummingbirds are found here than anywhere else in the United States. There are 384 species of reptiles, 37 of which are endemic, and 328 species of mammals, six of which are endemic. There are 84 fish species, 18 of which are endemic. Some 200 species of butterfly thrive here, of which 45 are endemic, including the Monarch that migrates 2,500 miles north to Canada each year.[illegible] Ecotourism has become the economic driver in many parts of this region, but logging, land clearing for agriculture, urban development, and now climate change threaten the region's viability.

becoming more variable, with a trend toward both more frequent extremely dry and extremely wet winters.[472] Some water systems rely on smaller reservoirs being filled up each year. More frequent dry winters suggest an increased risk of these systems running short of water. However, a greater potential for flooding also means reservoirs cannot be filled to capacity as safely in years where that is possible. Flooding also causes reservoirs to fill with sediment at a faster rate, thus reducing their water-storage capacities.

On the global and national scales, precipitation patterns are already observed to be shifting, with more rain falling in heavy downpours that can lead to flooding.[90,473] Rapid landscape transformation due to vegetation die-off and wildfire as well as loss of wetlands along rivers is also likely to reduce flood-buffering capacity. Moreover, increased flood risk in the Southwest is likely to result from a combination of decreased snow cover on the lower slopes of high mountains, and an increased fraction of winter precipitation falling as rain and therefore running off more rapidly.[154] The increase in rain on snow events will also result in rapid runoff and flooding.[474]

The most obvious impact of more frequent flooding is a greater risk to human beings and their infrastructure. This applies to locations along major rivers, but also to much broader and highly vulnerable areas such as the Sacramento–San Joaquin River Delta system. Stretching from the San Francisco Bay nearly to the state capital of Sacramento, the Sacramento–San Joaquin River Delta and Suisun Marsh make up the largest estuary on the West Coast of North America. With its rich soils and rapid subsidence rates – in some locations as high as 2 or more feet per decade – the entire Delta region is now below sea level, protected by more than a thousand miles of levees and dams.[475] Projected changes in the timing and amount of river flow, particularly in winter and spring, is estimated to more than double the risk of Delta flooding events by mid-century, and result in an eight-fold increase before the end of the century.[476] Taking into account the additional risk of a major seismic event and increases in sea level due to climate change over this century, the California Bay–Delta Authority has concluded that the Delta and Suisun Marsh are not sustainable under current practices; efforts are underway to identify and implement adaptation strategies aimed at reducing these risks.[476]

Unique tourism and recreation opportunities are likely to suffer.

Tourism and recreation are important aspects of the region's economy. Increasing temperatures will affect important winter activities such as downhill and cross-country skiing, snowshoeing, and snowmobiling, which require snow on the ground. Projections indicate later snow and less snow coverage in ski resort areas, particularly those at lower elevations and in the southern part of the region.[284] Decreases from 40 to almost 90 percent are likely in end-of-season snowpack under a higher emissions scenario[91] in counties with major ski resorts from New Mexico to California.[477] In addition to shorter seasons, earlier wet snow avalanches – more than six weeks earlier by the end of this century under a higher emissions scenario[91] – could force ski areas to shut down affected runs before the season would otherwise end.[478] Resorts require a certain number of days just to break even; cutting the season short by even a few weeks, particularly if those occur during the lucrative holiday season, could easily render a resort unprofitable.

Even in non-winter months, ecosystem degradation will affect the quality of the experience for hikers, bikers, birders, and others who enjoy the Southwest's natural beauty. Water sports that depend on the flows of rivers and sufficient water in lakes and reservoirs are already being affected, and much larger changes are expected.

Cities and agriculture face increasing risks from a changing climate.

Resource use in the Southwest is involved in a constant three-way tug-of-war among preserving natural ecosystems, supplying the needs of rapidly expanding urban areas, and protecting the lucrative agricultural sector, which, particularly in California, is largely based on highly temperature- and water-sensitive specialty crops. Urban areas are also sensitive to temperature-related impacts on air quality, electricity demand, and the health of their inhabitants.

The magnitude of projected temperature increases for the Southwest, particularly when combined with urban heat island effects for major cities such as Phoenix, Albuquerque, Las Vegas, and many California cities, represent significant stresses to health, electricity, and water supply in a region that already experiences very high summer temperatures.[284,325,450]

If present-day levels of ozone-producing emissions are maintained, rising temperatures also imply declining air quality in urban areas such as those in California which already experience some of the worst air quality in the nation (see *Society* sector).[479] Continued rapid population growth is expected to exacerbate these concerns.

With more intense, longer-lasting heat wave events projected to occur over this century, demands for air conditioning are expected to deplete electricity supplies, increasing risks of brownouts and blackouts.[325] Electricity supplies will also be affected by changes in the timing of river flows and where hydroelectric systems have limited storage capacity and reservoirs (see *Energy* sector).[480,481]

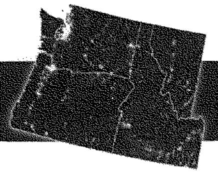
Much of the region's agriculture will experience detrimental impacts in a warmer future, particularly specialty crops in California such as apricots, almonds, artichokes, figs, kiwis, olives, and walnuts.[482,483] These and other specialty crops require a minimum number of hours at a chilling temperature threshold in the winter to become dormant and set fruit for the following year.[482] Accumulated winter chilling hours have already decreased across central California and its coastal valleys. This trend is projected to continue to the point where chilling thresholds for many key crops would no longer be met. A steady reduction in winter chilling could have serious economic impacts on fruit and nut production in the region. California's losses due to future climate change are estimated between zero and 40 percent for wine and table grapes, almonds, oranges, walnuts, and avocadoes, varying significantly by location.[483]

Adaptation strategies for agriculture in California include more efficient irrigation and shifts in cropping patterns, which have the potential to help compensate for climate-driven increases in water demand for agriculture due to rising temperatures.[484] The ability to use groundwater and/or water designated for agriculture as backup supplies for urban uses in times of severe drought is expected to become more important in the future as climate change dries out the Southwest; however, these supplies are at risk of being depleted as urban populations swell (see *Water* sector).

Strategies for Fire

Living with present-day levels of fire risk, along with projected increases in risk, involves actions by residents along the urban-forest interface as well as fire and land management officials. Some basic strategies for reducing damage to structures due to fires are being encouraged by groups like National Firewise Communities, an interagency program that encourages wildfire preparedness measures such as creating defensible space around residential structures by thinning trees and brush, choosing fire-resistant plants, selecting ignition-resistant building materials and design features, positioning structures away from slopes, and working with firefighters to develop emergency plans.

Additional strategies for responding to the increased risk of fire as climate continues to change could include adding firefighting resources[illegible] and improving evacuation procedures and communications infrastructure. Also important would be regularly updated insights into what the latest climate science implies for changes in types, locations, timing, and potential severity of fire risks over seasons to decades and beyond; implications for related political, legal, economic, and social institutions; and improving predictions for regeneration of burnt-over areas and the implications for subsequent fire risks. Reconsideration of policies that encourage growth of residential developments in or near forests is another potential avenue for adaptive strategies.[illegible]



Northwest

The Northwest's rapidly growing population, as well as its forests, mountains, rivers, and coastlines, are already experiencing human-induced climate change and its impacts.[34] Regionally averaged temperature rose about 1.5°F over the past century[485] (with some areas experiencing increases up to 4°F) and is projected to increase another 3 to 10°F during this century.[486] Higher emissions scenarios would result in warming in the upper end of the projected range. Increases in winter precipitation and decreases in summer precipitation are projected by many climate models,[487] though these projections are less certain than those for temperature. Impacts related to changes in snowpack, streamflows, sea level, forests, and other important aspects of life in the Northwest are already underway, with more severe impacts expected over coming decades in response to continued and more rapid warming.

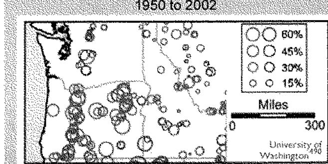
Declining springtime snowpack leads to reduced summer streamflows, straining water supplies.

The Northwest is highly dependent on temperature-sensitive springtime snowpack to meet growing, and often competing, water demands such as municipal and industrial uses, agricultural irrigation, hydropower production, navigation, recreation, and in-stream flows that protect aquatic ecosystems including threatened and endangered species. Higher cool season (October through March) temperatures cause more precipitation to fall as rain rather than snow and contribute to earlier snowmelt. April 1 snowpack, a key indicator of natural water storage available for the warm season, has already declined substantially throughout the region. The average decline in the Cascade Mountains, for example, was about 25 percent over the past 40 to 70 years, with most of this due to the 2.5°F increase in cool season temperatures over that period.[108,488] Further declines in Northwest snowpack are projected to result from additional warming over this century, varying with latitude, elevation, and proximity to the coast. April 1 snowpack is projected to decline as much as 40 percent in the Cascades by the 2040s.[489] Throughout the region, earlier snowmelt will cause a reduction in the amount of water available during the warm season.[68]

In areas where it snows, a warmer climate means major changes in the timing of runoff: streamflow increases in winter and early spring, and then decreases in late spring, summer, and fall. This shift in streamflow timing has already been observed over the past 50 years,[252] with the peak of spring runoff shifting from a few days earlier in some places to as much as 25 to 30 days earlier in others.[157]

This trend is projected to continue, with runoff shifting 20 to 40 days earlier within this century.[157] Reductions in summer water availability will vary with the temperatures experienced in different parts of the region. In relatively warm areas on the western slopes of the Cascade Mountains, for example, reductions in warm season (April through September) runoff of 30 percent or more are projected by mid-century, whereas colder areas in the Rocky Mountains are expected to see reductions of about 10 percent. Areas dominated by rain rather than snow are not expected to see major shifts in the timing of runoff.[492]

Trends in April 1 Snow Water Equivalent
1950 to 2002



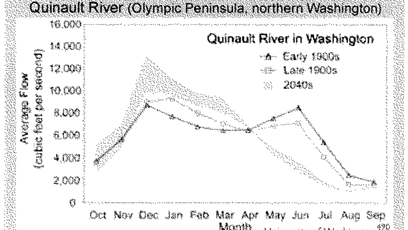
April 1 snowpack (a key indicator of natural water storage available for the warm season) has declined throughout the Northwest. In the Cascade Mountains, April 1 snowpack declined by an average of 25 percent, with some areas experiencing up to 60 percent declines. On the map, decreasing trends are in red and increasing trends are in blue.[491]

Extreme high and low streamflows also are expected to change with warming. Increasing winter rainfall (as opposed to snowfall) is expected to lead to more winter flooding in relatively warm watersheds on the west side of the Cascades. The already low flows of late summer are projected to decrease further due to both earlier snowmelt and increased evaporation and water loss from vegetation. Projected decreases in summer precipitation would exacerbate these effects. Some sensitive watersheds are projected to experience both increased flood risk in winter and increased drought risk in summer due to warming.

The region's water supply infrastructure was built based on the assumption that most of the water needed for summer uses would be stored naturally in snowpack. For example, the storage capacity in Columbia Basin reservoirs is only 30 percent of the annual runoff, and many small urban water supply systems on the west side of the Cascades store less than 10 percent of their annual flow.[493] Besides providing water supply and managing flows for hydropower, the region's reservoirs are operated for flood-protection purposes and, as such, might have to release (rather than store) large amounts of runoff during the winter and early spring to maintain enough space for flood protection. Earlier flows would thus place more of the year's runoff into the category of hazard rather than resource. An advance in the timing of snowmelt runoff would also

Shift to Earlier Peak Streamflow

Quinault River (Olympic Peninsula, northern Washington)



As precipitation continues to shift from snow to rain, by the 2040s, peak flow on the Quinault River is projected to occur in December, and flows in June are projected to be reduced to about half of what they were over the past century. On the graph, the blue swath represents the range of projected streamflows based on an increase in temperature of 3.6 to 5.4°F. The other lines represent streamflows in the early and late 1900s.[487,494]

increase the length of the summer dry period, with important consequences for water supply, ecosystems, and wildfire management.[157]

One of the largest demands on water resources in the region is hydroelectric power production. About 70 percent of the Northwest's electricity is provided by hydropower, a far greater percentage than in any other region. Warmer summers will increase electricity demands for air conditioning and refrigeration at the same time of year that lower streamflows will lead to reduced hydropower generation. At the same time, water is needed for irrigated agriculture, protecting fish species, reservoir and river recreation, and urban uses. Conflicts between all of these water uses are expected to increase, forcing complex trade-offs between competing objectives (see *Energy* and *Water* sectors).[487,494]

Increased insect outbreaks, wildfires, and changing species composition in forests will pose challenges for ecosystems and the forest products industry.

Higher summer temperatures and earlier spring snowmelt are expected to increase the risk of forest fires in the Northwest by increasing summer moisture deficits; this pattern has already been observed in recent decades. Drought stress and higher temperatures will decrease tree growth in most low- and mid-elevation forests. They will also increase the frequency and intensity of mountain pine beetle and other insect attacks,[243] further increasing fire risk and reducing timber production, an important part of the regional economy. The mountain pine beetle outbreak in British Columbia has destroyed 33 million acres of trees so far, about 40 percent of the marketable pine trees in the province. By 2018, it is projected that the infestation will have run its course and over 78 percent of the mature pines will have been killed; this will affect more than one-third of the total area of British Columbia's forests[495] (see *Ecosystems* sector). Forest and fire management practices are also factors in these insect outbreaks.[252] Idaho's Sawtooth Mountains are also now threatened by pine beetle infestation.

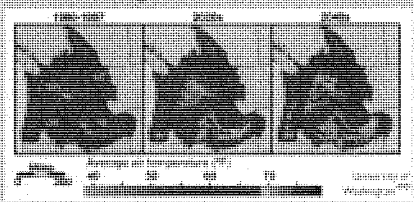
In the short term, high elevation forests on the west side of the Cascade Mountains are expected to see increased growth. In the longer term, forest growth is expected to decrease as summertime soil moisture deficits limit forest productivity, with low-elevation forests experiencing these changes first. The extent and species composition of forests are also expected to change as tree species respond to climate change. There is also the potential for extinction of local populations and loss of biological diversity if environmental changes outpace species' ability to shift their ranges and form successful new ecosystems.

Agriculture, especially production of tree fruit such as apples, is also an important part of the regional economy. Decreasing irrigation supplies, increasing pests and disease, and increased competition from weeds are likely to have negative effects on agricultural production.

Salmon and other coldwater species will experience additional stresses as a result of rising water temperatures and declining summer streamflows.

Northwest salmon populations are at historically low levels due to stresses imposed by a variety of human activities including dam building, logging, pollution, and over-fishing. Climate change affects salmon throughout their life stages and poses an additional stress. As more winter precipitation falls as rain rather than snow, higher winter streamflows scour streambeds, damaging spawning nests and washing away incubating eggs. Earlier peak streamflows flush young salmon from rivers to estuaries before they are physically mature enough for the transition, increasing a variety of stresses including the risk of being eaten by predators. Lower summer streamflows and warmer water temperatures create less favorable summer stream conditions for salmon and other coldwater fish species in many parts of the Northwest. In addition, diseases and parasites that infect salmon tend to flourish in warmer water. Climate change also impacts the ocean environment, where salmon spend several years of their lives. Historically, warm periods in the coastal ocean have coincided with relatively low abundances of salmon, while cooler ocean periods have coincided with relatively high salmon numbers.[70, 563]

Decreasing Habitat for Coldwater Fish

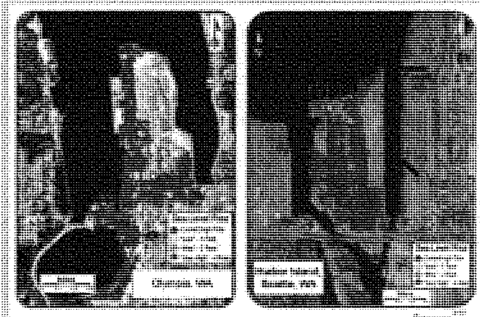


Most wild Pacific salmon populations are extinct or imperiled in 56 percent of their historical range in the Northwest and California,[496] and populations are down more than 90 percent in the Columbia River system. Many species are listed as either threatened or endangered under the Federal Endangered Species Act. Studies suggest that about one-third of the current habitat for the Northwest's salmon and other coldwater fish will no longer be suitable for them by the end of this century as key temperature thresholds are exceeded. Because climate change impacts on their habitat are projected to be negative, climate change is expected to hamper efforts to restore depleted salmon populations.

Sea-level rise along vulnerable coastlines will result in increased erosion and the loss of land.

Climate change is projected to exacerbate many of the stresses and hazards currently facing the coastal zone. Sea-level rise will increase erosion of the Northwest coast and cause the loss of beaches and significant coastal land areas. Among the most vulnerable parts of the coast is the heavily populated south Puget Sound region, which includes the cities of Olympia, Tacoma, and Seattle, Washington. Some climate models project changes in atmospheric pressure patterns that suggest a more southwesterly direction of future winter winds. Combined with higher sea levels, this would accelerate coastal erosion all along the Pacific Coast. Sea-level rise in the Northwest (as elsewhere) is determined by global rates of sea-level rise, changes in coastal elevation associated with local vertical movement of the land, and atmospheric circulation patterns that influence wind-driven "pile-up" of water along the coast. A mid-range estimate of relative sea-level rise for the Puget Sound basin is about 13 inches by 2100. However, higher levels of up to 50 inches by 2100 in more rapidly subsiding (sinking) portions of the basin are also possible given the large uncertainties about accelerating rates of ice melt from Greenland and Antarctica in recent years (see *Global* and *National Climate Change* sections).[498]

Northwest Cities at Risk to Sea-Level Rise



Highly populated coastal areas throughout Puget Sound, Washington, are vulnerable to sea-level rise. The maps show regions of Olympia and Harbor Island (both located in Puget Sound) that are likely to be lost to sea-level rise by the end of this century based on moderate and high estimates.

An additional concern is landslides on coastal bluffs. The projected heavier winter rainfall suggests an increase in saturated soils and, therefore, an increased number of landslides. Increased frequency and/or severity of landslides is expected to be especially problematic in areas where there has been intensive development on unstable slopes. Within Puget Sound, the cycle of beach erosion and bluff landslides will be exacerbated by sea-level rise, increasing beach erosion, and decreasing slope stability.

Adaptation: Improved Planning to Cope with Future Changes

States, counties, and cities in the Northwest are beginning to develop strategies to adapt to climate change. In 2007, Washington state convened stakeholders to develop adaptation strategies for water, agriculture, forests, coasts, infrastructure, and human health. Recommendations included improved drought planning, improved monitoring of diseases and pests, incorporating sea-level rise in coastal planning, and public education. An implementation strategy is under development.

In response to concerns about increasing flood risk, King County, Washington, approved plans in 2007 to fund repairs to the county's aging levee system. The county also will replace more than 37 "short-span" bridges with wider span structures that allow more debris and floodwater to pass underneath rather than backing up and causing the river to flood. The county has begun incorporating porous concrete and rain gardens into road projects to manage the effects of stormwater runoff during heavy rains, which are increasing as climate changes. King County has also published an adaptation guidebook that is becoming a model that other local governments can refer to in order to organize adaptation actions within their municipal planning processes.

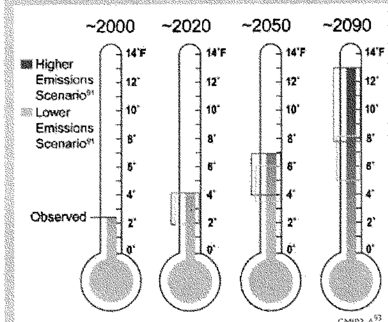
Concerns about sea-level rise in Olympia, Washington, contributed to the city's decision to relocate its primary drinking water source from a low-lying surface water source to wells on higher ground. The city adjusted its plans for construction of a new City Hall to locate the building in an area less vulnerable to sea-level rise than the original proposed location. The building's foundation also was raised by 1 foot.

Alaska

Over the past 50 years, Alaska has warmed at more than twice the rate of the rest of the United States' average. Its annual average temperature has increased 3.4°F, while winters have warmed even more, by 6.3°F.[501] As a result, climate change impacts are much more pronounced than in other regions of the United States. The higher temperatures are already contributing to earlier spring snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming.[220,501] These observed changes are consistent with climate model projections of greater warming over Alaska, especially in winter, as compared to the rest of the country.

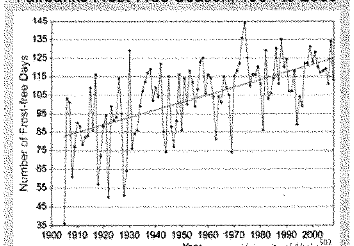
Climate models also project increases in precipitation over Alaska. Simultaneous increases in evaporation due to higher air temperatures, however, are expected to lead to drier conditions overall, with reduced soil moisture.[90] In the future, therefore, model projections suggest a longer summer growing season combined with an increased likelihood of summer drought and wildfires.

Observed and Projected Temperature Rise



Alaska's annual average temperature has increased 3.4°F over the past 50 years. The observed increase shown above compares the average temperature of 1993-2007 with a 1960s-1970s baseline, an increase of over 2°F. The brackets on the thermometers represent the likely range of model projections, though lower or higher outcomes are possible. By the end of this century, the average temperature is projected to rise by 5 to 13°F above the 1960s-1970s baseline.

Fairbanks Frost-Free Season, 1904 to 2008



Over the past 100 years, the length of the frost-free season in Fairbanks, Alaska, has increased by 50 percent. The trend toward a longer frost-free season is projected to produce benefits in some sectors and detriments in others.

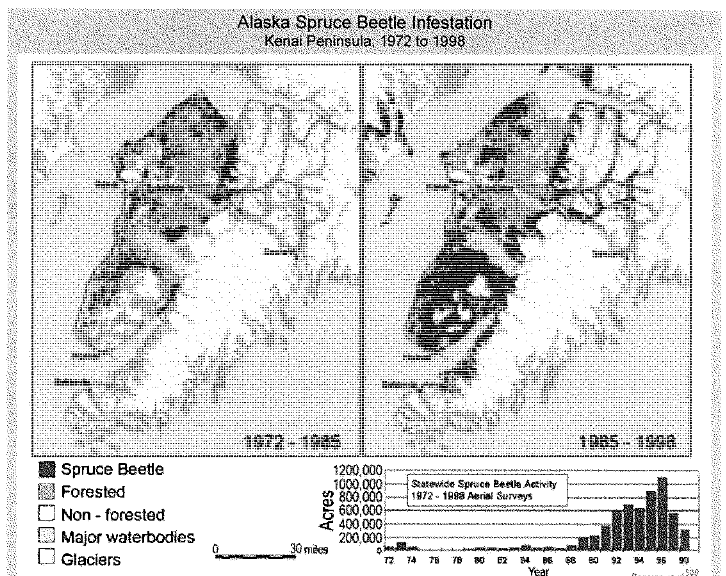
Average annual temperatures in Alaska are projected to rise about 3.5 to 7°F by the middle of this century. How much temperatures rise later in the century depends strongly on global emissions choices, with increases of 5 to 8°F projected with lower emissions, and increases of 8 to 13°F with higher emissions.[91] Higher temperatures are expected to continue to reduce Arctic sea ice coverage. Reduced sea ice provides opportunities for increased shipping and resource extraction. At the same time, it increases coastal erosion[522] and flooding associated with coastal storms. Reduced sea ice also alters the timing and location of plankton blooms, which is expected to drive major shifts of marine species such as pollock and other commercial fish stocks.[527]

Longer summers and higher temperatures are causing drier conditions, even in the absence of strong trends in precipitation.

Between 1970 and 2000, the snow-free season increased by approximately 10 days across Alaska, primarily due to earlier snowmelt in the spring.[503,504] A longer growing season has potential economic benefits, providing a longer period of outdoor and commercial activity such as tourism. However, there are also downsides. For example, white spruce forests in Alaska's interior are experiencing declining growth due to drought stress[505] and continued warming could lead to widespread death of trees.[506] The decreased soil moisture in Alaska also suggests that agriculture in Alaska might not benefit from the longer growing season.

Insect outbreaks and wildfires are increasing with warming.

Climate plays a key role in determining the extent and severity of insect outbreaks and wildfires.[506,507] During the 1990s, for example, south-central Alaska experienced the largest outbreak of spruce beetles in the world.[243,506] This outbreak occurred because rising temperatures allowed the spruce beetle to survive over the winter and to complete its life cycle in just one year instead of the normal two years. Healthy trees ordinarily defend themselves by pushing back against burrowing beetles with their pitch. From 1989 to 1997, however, the region experienced an extended drought, leaving the trees too stressed to fight off the infestation.



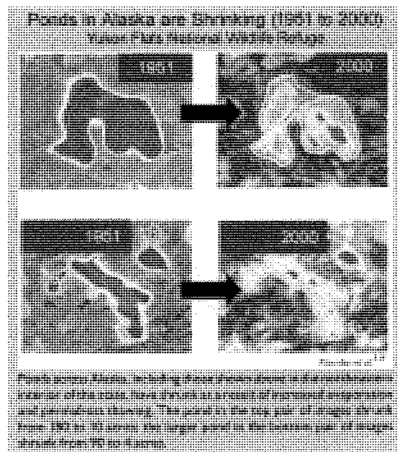
Warming in Alaska has caused insect outbreaks to increase. Red areas indicate spruce beetle infestations on the Kenai Peninsula. Over 5 million acres of Alaska spruce forests were destroyed.

Prior to 1990, the spruce budworm was not able to reproduce in interior Alaska.[506] Hotter, drier summers, however, now mean that the forests there are threatened by an outbreak of spruce budworms.[509] This trend is expected to increase in the future if summers in Alaska become hotter and drier.[506] Large areas of dead trees, such as those left behind by pest infestations, are highly flammable and thus much more vulnerable to wildfire than living trees.

The area burned in North America's northern forest that spans Alaska and Canada tripled from the 1960s to the 1990s. Two of the three most extensive wildfire seasons in Alaska's 56-year record occurred in 2004 and 2005, and half of the most severe fire years on record have occurred since 1990.[510] Under changing climate conditions, the average area burned per year in Alaska is projected to double by the middle of this century.[507] By the end of this century, area burned by fire is projected to triple under a moderate greenhouse gas emissions scenario and to quadruple under a higher emissions scenario.[91] Such increases in area burned would result in numerous impacts, including hazardous air quality conditions such as those suffered by residents of Fairbanks during the summers of 2004 and 2005, as well as increased risks to rural Native Alaskan communities because of reduced availability of the fish and game that make up their diet. This would cause them to adopt a more "Western" diet,[511] known to be associated with increased risk of cancers, diabetes, and cardiovascular disease.[512]

Lakes are declining in area.

Across the southern two-thirds of Alaska, the area of closed-basin lakes (lakes without stream inputs and outputs) has decreased over the past 50 years. This is likely due to the greater evaporation and thawing of permafrost that result from warming.[513,514] A continued decline in the area of surface water would present challenges for the management of natural resources and ecosystems on National Wildlife Refuges in Alaska. These refuges, which cover over 77 million acres (21 percent of Alaska) and comprise 81 percent of the U.S. National Wildlife Refuge System, provide breeding habitat for millions of waterfowl and shorebirds that winter in the lower 48 states. Wetlands are



also important to Native peoples who hunt and fish for their food in interior Alaska. Many villages are located adjacent to wetlands that support an abundance of wildlife resources. The sustainability of these traditional lifestyles is thus threatened by a loss of wetlands.

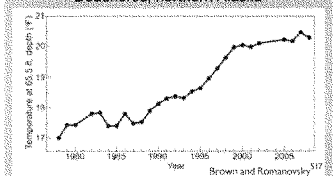
Thawing permafrost damages roads, runways, water and sewer systems, and other infrastructure.

Permafrost temperatures have increased throughout Alaska since the late 1970s.[149] The largest increases have been measured in the northern part of the state.[515] While permafrost in interior Alaska so far has experienced less warming than permafrost in northern Alaska, it is more vulnerable to thawing during this century because it is generally just below the freezing point, while permafrost in northern Alaska is colder.

Land subsidence (sinking) associated with the thawing of permafrost presents substantial challenges to engineers attempting to preserve infrastructure in Alaska.[516] Public infrastructure at risk for damage includes roads, runways, and water and sewer systems. It is estimated that thawing

Permafrost Temperature, 1978 to 2008

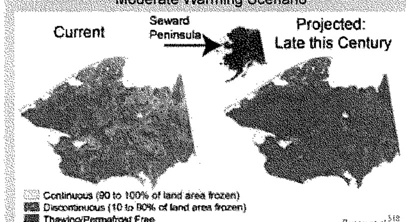
Deadhorse, northern Alaska



Permafrost temperatures have risen throughout Alaska, with the largest increases in the northern part of the state.

Changing Permafrost Distribution

Moderate Warming Scenario



The maps show projected thawing on the Seward Peninsula by the end of this century under a moderate warming scenario approximately half-way between the lower and higher emissions scenarios[91] described on page 23.

permafrost would add between $3.6 billion and $6.1 billion (10 to 20 percent) to future costs for publicly owned infrastructure by 2030 and between $5.6 billion and $7.6 billion (10 to 12 percent) by 2080.[230] Analyses of the additional costs of permafrost thawing to private property have not yet been conducted.

Thawing ground also has implications for oil and gas drilling. As one example, the number of days per year in which travel on the tundra is allowed under Alaska Department of Natural Resources standards has dropped from more than 200 to about 100 days in the past 30 years. This results in a 50 percent reduction in days that oil and gas exploration and extraction equipment can be used.[220,245]

Thawing permafrost can push natural ecosystems across thresholds. Some forests in Alaska are literally toppling over as the permafrost beneath them thaws, undermining the root systems of trees (see photo next page).

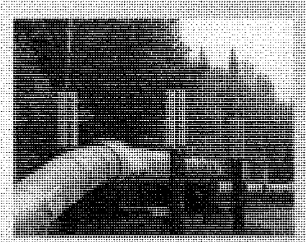
Coastal storms increase risks to villages and fishing fleets.

Alaska has more coastline than the other 49 states combined. Frequent storms in the Gulf of Alaska and the Bering, Chukchi, and Beaufort Seas already affect the coasts during much of the year. Alaska's coastlines, many of which are low in elevation, are increasingly threatened by a combination of the loss of their protective sea ice buffer, increasing storm activity, and thawing coastal permafrost.

Increasing storm activity in autumn in recent years[520] has delayed or prevented barge operations

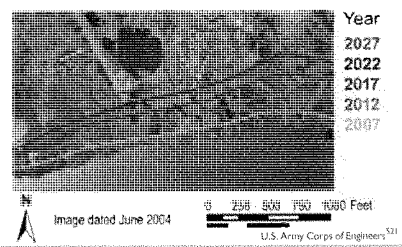
Keeping Soil Around the Pipeline Cool

When permafrost thaws, it can cause the soil to sink or settle, damaging structures built upon or within that soil. A warming climate and burial of supports for the Trans-Alaska Pipeline System both contribute to thawing of the permafrost around the pipeline. In locations on the pipeline route where soils were ice-rich, a unique above-ground system was developed to keep the ground cool. Thermal siphons were designed to disperse heat to the air that would otherwise be transferred to the soil, and these siphons were placed on the pilings that support the pipeline. While this unique technology added significant expense to the pipeline construction, it helps to greatly increase the useful lifetime of this structure.



Leaning trees in this Alaska forest tilt because the ground beneath them, which used to be permanently frozen, has thawed. Forests like this are named "drunken forests."

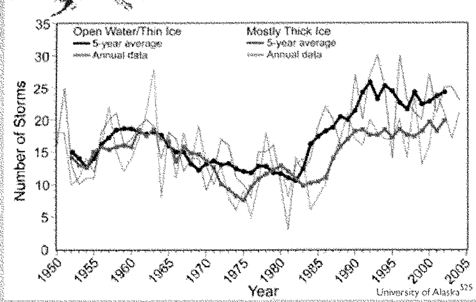
Projected Coastal Erosion, 2007 to 2027
Newtok, western Alaska



Many of Alaska's coastlines are eroding rapidly; the disappearance of coastal land is forcing communities to relocate. The 2007 line on the image indicates where Newtok, Alaska's shoreline had eroded to by 2007. The other lines are projected assuming a conservative erosion rate of 36 to 83 feet per year; however, Newtok residents reported a July 2003 erosion rate of 110 feet per year.

that supply coastal communities with fuel. Commercial fishing fleets and other marine traffic are also strongly affected by Bering Sea storms. High-wind events have become more frequent along the western and northern coasts. The same regions are experiencing increasingly long sea-ice-free seasons and hence longer periods during which coastal areas are especially vulnerable to wind and wave damage. Downtown streets in Nome, Alaska, have flooded in recent years. Coastal erosion is causing the shorelines of some areas to retreat at average rates of tens of feet per year. The ground beneath several native communities is literally crumbling into the sea, forcing residents to confront difficult and expensive choices between relocation and engineering strategies that require continuing investments despite their uncertain effectiveness (see *Society* sector). The rate of erosion along Alaska's northeastern coastline has doubled over the past 50 years.[522]

Annual Number of Storms at Barrow, Alaska, 1950-2004
(northernmost town in the United States)



The number of coastal storms has generally increased as the amount of ice along the coast has decreased. This increase threatens commercial activity and communities in Alaska. The blue line indicates the annual number of open-water storms, those occurring in primarily ice-free water (July to December). The purple line indicates the number of storms occurring when thick sea ice is present (January to June). The black and green lines are smoothed using 5-year averages.

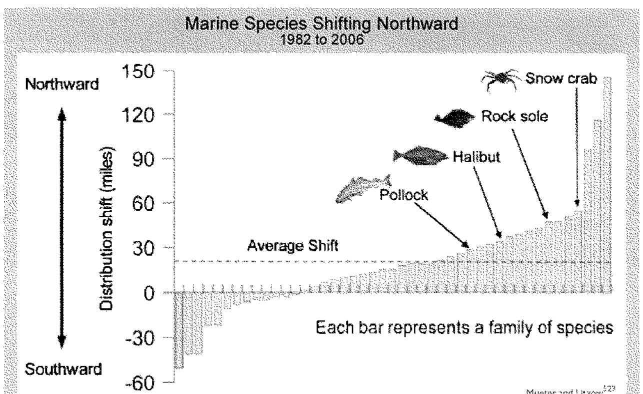
Over this century, an increase of sea surface temperatures and a reduction of ice cover are likely to lead to northward shifts in the Pacific storm track and increased impacts on coastal Alaska.[523,524] Climate models project the Bering Sea to experience the largest decreases in atmospheric pressure in the Northern Hemisphere, suggesting an increase in storm activity in the region.[90] In addition, the longer ice-free season is likely to make more heat and moisture available for storms in the Arctic Ocean, increasing their frequency and/or intensity.

Displacement of marine species will affect key fisheries.

Alaska leads the United States in the value of its commercial fishing catch. Most of the nation's salmon, crab, halibut, and herring come from Alaska. In addition, many Native communities depend on local harvests of fish, walruses, seals, whales, seabirds, and other marine species for their food supply. Climate change causes significant alterations in marine ecosystems with important implications for fisheries. Ocean acidification associated with a rising carbon dioxide concentration represents an additional threat to coldwater marine ecosystems[23,526] (see *Ecosystems* sector and *Coasts* region).

One of the most productive areas for Alaska fisheries is the northern Bering Sea off Alaska's west coast. The world's largest single fishery is the Bering Sea pollock fishery, which has undergone major declines in recent years. Over much of the past decade, as air and water temperatures rose, sea ice in this region declined sharply. Populations of fish, seabirds, seals, walruses, and other species depend on plankton blooms that are regulated by the extent and location of the ice edge in spring. As the sea ice retreats, the location, timing, and species composition of the plankton blooms changes, reducing the amount of food reaching the living things on the ocean floor. This radically changes the species composition and populations of fish and other marine life forms, with significant repercussions for fisheries[527] (see *Ecosystems* sector).

Over the course of this century, changes already observed on the shallow shelf of the northern Bering Sea are likely to affect a much broader portion of the Pacific-influenced sector of the Arctic Ocean. As such changes occur, the most productive commercial fisheries are likely to become more distant from existing fishing ports and processing infrastructure, requiring either relocation or greater investment in transportation time and fuel costs. These changes will also affect the ability of Native Peoples to successfully hunt and fish for the food they need to survive. Coastal communities are already noticing a displacement of walrus and seal populations. Bottom-feeding walrus populations are threatened when their sea ice platform retreats from the shallow coastal feeding grounds on which they depend.[528]



As air and water temperatures rise, marine species are moving northward, affecting fisheries, ecosystems, and coastal communities that depend on the food source. On average, by 2006, the center of the range for the examined species moved 19 miles north of their 1982 locations.

Islands

Climate change presents the Pacific and Caribbean islands with unique challenges. The U.S. affiliated Pacific Islands are home to approximately 1.7 million people in the Hawaiian Islands; Palau; the Samoan Islands of Tutuila, Manua, Rose, and Swains; and islands in the Micronesian archipelago, the Carolines, Marshalls, and Marianas.[530] These include volcanic, continental, and limestone islands, atolls, and islands of mixed geologies.[530] The degree to which climate change and variability will affect each of the roughly 30,000 islands in the Pacific depends upon a variety of factors, including the island's geology, area, height above sea level, extent of reef formation, and the size of its freshwater aquifer.[531]

In addition to Puerto Rico and the U.S. Virgin Islands, there are 40 island nations in the Caribbean that are home to approximately 38 million people.[532] Population growth, often concentrated in coastal areas, escalates the vulnerability of both Pacific and Caribbean island communities to the effects of climate change, as do weakened traditional support systems. Tourism and fisheries, both of which are climate-sensitive, play a large economic role in these communities.[530]

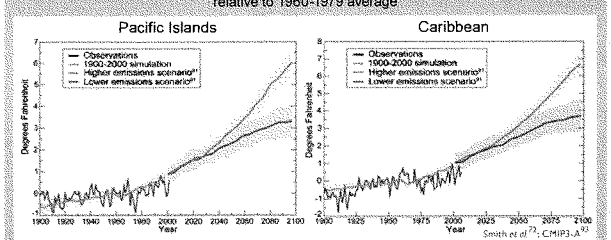
Small islands are considered among the most vulnerable to climate change because extreme events have major impacts on them. Changes in weather patterns and the frequency and intensity of extreme events, sea-level rise, coastal erosion, coral reef bleaching, ocean acidification, and contamination of freshwater resources by salt water are among the impacts small islands face.[533]

Islands have experienced rising temperatures and sea levels in recent decades. Projections for the rest of this century suggest:

- Increases in air and ocean surface temperatures in both the Pacific and Caribbean;[90]
- An overall decrease in rainfall in the Caribbean; and
- An increased frequency of heavy downpours and increased rainfall during summer months (rather than the normal rainy season in winter months) for the Pacific (although the range of projections regarding rainfall in the Pacific is still quite large).

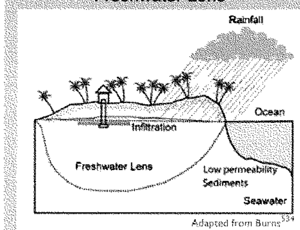
The number of heavy rain events is very likely to increase.[90] Hurricane (typhoon) wind speeds and rainfall rates are likely to increase with continued

Air Temperature Change, Observed and Projected, 1900 to 2100
relative to 1960-1979 average



Air temperatures have increased over the last 100 years in both the Pacific Island and Caribbean regions. Larger increases are projected in the future, with higher emissions scenarios[91] producing considerably greater increases. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models.

Freshwater Lens



Many island communities depend on freshwater lenses, which are recharged by precipitation. The amount of water a freshwater lens contains is determined by the size of the island, the amount of rainfall, rates of water withdrawal, the permeability of the rock beneath the island, and salt mixing due to storm- or tide-induced pressure. Freshwater lenses can be as shallow as 4 to 8 inches or as deep as 65 feet.[534]

warming.[68] Islands and other low-lying coastal areas will be at increased risk from coastal inundation due to sea-level rise and storm surge, with major implications for coastal communities, infrastructure, natural habitats, and resources.

The availability of freshwater is likely to be reduced, with significant implications for island communities, economies, and resources.

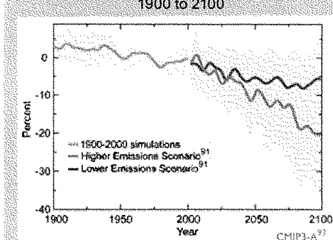
Most island communities in the Pacific and the Caribbean have limited sources of the freshwater needed to support unique ecosystems and biodiversity, public health, agriculture, and tourism. Conventional freshwater resources include rainwater collection, groundwater, and surface water.[534] For drinking and bathing, smaller Pacific islands primarily rely on individual rainwater catchment systems, while groundwater from the freshwater lens is used for irrigation. The size of freshwater lenses in atolls is influenced by factors such as rates of recharge (through precipitation), rates of use, and extent of tidal inundation.[531] Since rainfall triggers the formation of the freshwater lens, changes in precipitation, such as the significant decreases projected for the Caribbean, can significantly affect the availability of water. Because tropical storms replenish water supplies, potential changes in these storms are a great concern.

While it might initially be seen as a benefit, increased rainfall in the Pacific Islands during the summer months is likely to result in increased flooding, which would reduce drinking water quality and crop yields.[534] In addition, many islands have weak distribution systems and old infrastructure, which result in significant water leakage, decreasing their ability to use freshwater efficiently. Water pollution (such as from agriculture or sewage), exacerbated by storms and floods, can contaminate the freshwater supply, affecting public health. Sea-level rise also affects island water supplies by causing salt water to contaminate the freshwater lens and by causing an increased frequency of flooding due to storm high tides.[531] Finally, a rapidly rising population is straining the limited water resources, as would an increased incidence and/or intensity of storms[534] or periods of prolonged drought.

Island communities, infrastructure, and ecosystems are vulnerable to coastal inundation due to sea-level rise and coastal storms.

Sea-level rise will have enormous effects on many island nations. Flooding will become more frequent due to higher storm tides, and coastal land will be permanently lost as the sea inundates low-lying areas and the shorelines erode. Loss of land

Caribbean Precipitation Change
1900 to 2100



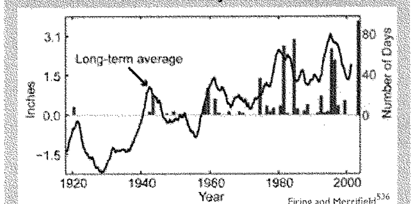
Total annual precipitation has declined in the Caribbean and climate models project stronger declines in the future, particularly under higher emission scenarios.[91] Such decreases threaten island communities that rely on rainfall for replenishing their freshwater supplies. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models.

will reduce freshwater supplies[531] and affect living things in coastal ecosystems. For example, the Northwestern Hawaiian Islands, which are low-lying and therefore at great risk from increasing sea level, have a high concentration of endangered and threatened species, some of which exist nowhere else.[535] The loss of nesting and nursing habitat is expected to threaten the survival of already vulnerable species.[535]

In addition to gradual sea-level rise, extreme high water level events can result from a combination of coastal processes.[271] For example, the harbor in Honolulu, Hawaii, experienced the highest daily average sea level ever recorded in September 2003. This resulted from the combination of long-term sea-level rise, normal seasonal heating (which causes the volume of water to expand and thus the level of the sea to rise), seasonal high tide, and an ocean circulation event which temporarily raised local sea level.[536] The interval between such extreme events has decreased from more than 20 years to approximately 5 years as average sea level has risen.[536]

Hurricanes, typhoons, and other storm events, with their intense precipitation and storm surge, cause major impacts to Pacific and Caribbean island communities, including loss of life, damage to infrastructure and property, and contamination of freshwater supplies.[537] As the climate continues to warm, the peak wind intensities and near-storm precipitation from future tropical cyclones are likely to increase,[90] which, combined with sea-level rise, is expected to cause higher storm surge levels. If such events occur frequently, communities would face challenges in recovering between events, resulting in long-term deterioration of infrastructure, freshwater and agricultural resources, and other impacts.[246]

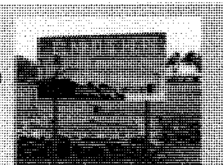
Extreme Sea-Level Days: Honolulu, Hawaii



Sea-level rise will result in permanent land loss and reductions in freshwater supplies, as well as threaten coastal ecosystems. "Extreme" sea-level days (with a daily average of more than 6 inches above the long-term average[90]) can result from the combined effects of gradual sea-level rise due to warming and other phenomena, including seasonal heating and high tides.

Adapting: Securing Water Resources

In the islands, "water is gold." Effective adaptation to climate-related changes in the availability of freshwater is thus a high priority. While island communities cannot completely counter the threats to water supplies posed by global warming, effective adaptation approaches can help reduce the damage.



[illegible]

When existing resources fall short, managers look to unconventional resources, such as desalinating seawater, importing water by ship, and using treated wastewater for non-drinking uses. Desalination costs are declining, though concerns remain about the impact on marine life, the disposal of concentrated brines that may contain chemical waste, and the large energy use (and associated carbon footprint) of the process.[illegible] With limited natural resources, the key to successful water resource management in the islands will continue to be "conserve, recover, and reuse."[illegible]

Pacific Island communities are also making use of the latest science. This effort started during the 1997 to 1998 El Niño, when managers began using seasonal forecasts to prepare for droughts by increasing public awareness and encouraging water conservation. In addition, resource managers can improve infrastructure, such as by fixing water distribution systems to minimize leakage and by increasing freshwater storage capacity.[illegible]

Coastal houses and an airport in the U.S.-affiliated Federated States of Micronesia rely on mangroves' protection from erosion and damage due to rising sea level, waves, storm surges, and wind.

Critical infrastructure, including homes, airports, and roads, tends to be located along the coast. Flooding related to sea-level rise and hurricanes and typhoons negatively affects port facilities and harbors, and causes closures of roads, airports, and bridges.[538] Long-term infrastructure damage would affect social services such as disaster risk management, health care, education, management of freshwater resources, and economic activity in sectors such as tourism and agriculture.

Climate changes affecting coastal and marine ecosystems will have major implications for tourism and fisheries.

Marine and coastal ecosystems of the islands are particularly vulnerable to the impacts of climate change. Sea-level rise, increasing water temperatures, rising storm intensity, coastal inundation and flooding from extreme events, beach erosion, ocean acidification, increased incidences of coral disease, and increased invasions by non-native species are among the threats that endanger the ecosystems that provide safety, sustenance, economic viability, and cultural and traditional values to island communities.[539]

Tourism is a vital part of the economy for many islands. In 1999, the Caribbean had tourism-based gross earnings of $17 billion, providing 900,000 jobs and making the Caribbean one of the most tourism dependent regions in the world.[532] In the South Pacific, tourism can contribute as much as 47 percent of gross domestic product.[540] In Hawaii, tourism generated $12.4 billion for the state in 2006, with over 7 million visitors.[541]

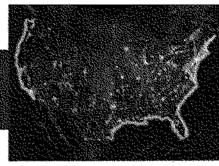
Sea-level rise can erode beaches, and along with increasing water temperatures, can destroy or degrade natural resources such as mangroves and coral reef ecosystems that attract tourists.[246] Extreme weather events can affect transportation systems and interrupt communications. The availability of freshwater is critical to sustaining tourism, but is subject to the climate-related impacts described on the previous page. Public health concerns about diseases would also negatively affect tourism.

Coral reefs sustain fisheries and tourism, have biodiversity value, scientific and educational value, and form natural protection against wave erosion.[542] For Hawaii alone, net benefits of reefs to the economy are estimated at $360 million annually, and the overall asset value is conservatively estimated to be nearly $10 billion.[542] In the Caribbean, coral reefs provide annual net benefits from fisheries, tourism, and shoreline protection services of between $3.1 billion and $4.6 billion. The loss of income by 2015 from degraded reefs is conservatively estimated at several hundred million dollars annually.[532,543]

Coral reef ecosystems are particularly susceptible to the impacts of climate change, as even small increases in water temperature can cause coral bleaching,[544] damaging and killing corals. Ocean acidification due to a rising carbon dioxide concentration poses an additional threat (see *Ecosystems* sector and *Coasts* region). Coral reef ecosystems are also especially vulnerable to invasive species.[545] These impacts, combined with changes in the occurrence and intensity of El Niño events, rising sea level, and increasing storm damage,[246] will have major negative effects on coral reef ecosystems.

Fisheries feed local people and island economies. Almost all communities within the Pacific Islands derive over 25 percent of their animal protein from fish, with some deriving up to 69 percent.[546] For island fisheries sustained by healthy coral reef and marine ecosystems, climate change impacts exacerbate stresses such as overfishing,[246] affecting both fisheries and tourism that depend on abundant and diverse reef fish. The loss of live corals results in local extinctions and a reduced number of reef fish species.[547]

Nearly 70 percent of the world's annual tuna harvest, approximately 3.2 million tons, comes from the Pacific Ocean.[548] Climate change is projected to cause a decline in tuna stocks and an eastward shift in their location, affecting the catch of certain countries.[246]



Coasts

Approximately one-third of all Americans live in counties immediately bordering the nation's ocean coasts.[549,550] In addition to accommodating major cities, the coasts and the exclusive economic zone extending 200 miles offshore provide enjoyment, recreation, seafood, transportation of goods, and energy. Coastal and ocean activities contribute more than $1 trillion to the nation's gross domestic product and the ecosystems hold rich biodiversity and provide invaluable services.[551] However, intense human uses have taken a toll on coastal environments and their resources. Many fish stocks have been severely diminished by over-fishing, large "dead zones" depleted of oxygen have developed as a result of pollution by excess nitrogen runoff, toxic blooms of algae are increasingly frequent, and coral reefs are badly damaged or becoming overgrown with algae. About half of the nation's coastal wetlands have been lost – and most of this loss has occurred during the past 50 years.

Global climate change imposes additional stresses on coastal environments. Rising sea level is already eroding shorelines, drowning wetlands, and threatening the built environment.[43,224] The destructive potential of Atlantic tropical storms and hurricanes has increased since 1970 in association with increasing Atlantic sea surface temperatures, and it is likely that hurricane rainfall and wind speeds will increase in response to global warming.[112] Coastal water temperatures have risen by about 2°F in several regions, and the geographic distributions of marine species have shifted.[37,68,347] Precipitation increases on land have increased river runoff, polluting coastal waters with more nitrogen and phosphorous, sediments, and other contaminants. Furthermore, increasing acidification resulting from the uptake of carbon dioxide by ocean waters threatens corals, shellfish, and other living things that form their shells and skeletons from calcium carbonate[23] (see *Ecosystems* sector). All of these forces converge and interact at the coasts, making these areas particularly sensitive to the impacts of climate change.

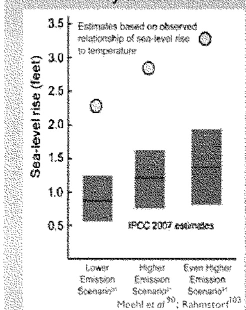
Significant sea-level rise and storm surge will adversely affect coastal cities and ecosystems around the nation; low-lying and subsiding areas are most vulnerable.

The rise in sea level relative to the land surface in any given location is a function of both the amount of global average sea-level rise and the degree to which the land is rising or falling. During the past century in the United States, relative sea level changes ranged from falling several inches to rising as much as 2 feet.[225] High rates of relative sea-level rise, coupled with cutting off the supply of sediments from the Mississippi River and other human alterations, have resulted in the loss of 1,900 square miles of Louisiana's coastal wetlands during the past century, weakening their capacity

Multiple Stressors Confront Coastal Regions

Various forces of climate change at the coasts pose a complex array of management challenges and adaptation requirements. For example, relative sea level is expected to rise at least 2 feet in Chesapeake Bay (located between Maryland and Virginia) where the land is subsiding, threatening portions of cities, inhabited islands, most tidal wetlands, and other low-lying regions. Climate change also will affect the volume of the bay, its salinity distribution and circulation, as will changes in precipitation and freshwater runoff. These changes, in turn, will affect summer-time oxygen depletion and efforts to reduce the agricultural nitrogen runoff that causes it. Meanwhile the warming of the bay's waters will make survival there difficult for northern species such as eelgrass and soft clams, while allowing southern species and invaders riding in ships' ballast water to move in and change the mix of species that are caught and must be managed. Additionally, more acidic waters resulting from rising carbon dioxide levels will make it difficult for oysters to build their shells and will complicate the recovery of this key species.

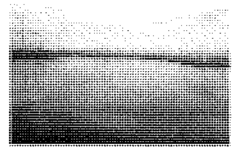
Projected Sea-Level Rise by 2100



Meehl et al.[90]; Rahmstorf[103]

Estimates of sea-level rise by the end of the century for three emissions scenarios.[91] Intergovernmental Panel on Climate Change 2007 projections (range shown as bars) exclude changes in ice sheet flow.[90] Light blue circles represent more recent, central estimates derived using the observed relationship of sea-level rise to temperature.[103] Areas where coastal land is sinking, for example by as much as 1.5 feet in this century along portions of the Gulf Coast, would experience that much additional sea-level rise relative to the land.[128]

to absorb the storm surge of hurricanes such as Katrina.[552] Shoreline retreat is occurring along most of the nation's exposed shores.



A "ghost swamp" in south Louisiana shows the effects of saltwater intrusion.

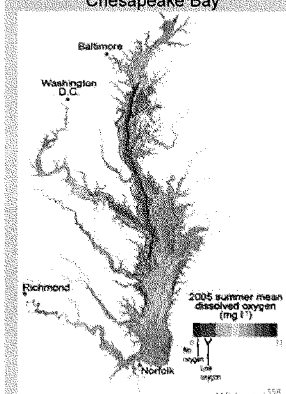
The amount of sea-level rise likely to be experienced during this century depends mainly on the expansion of the ocean volume due to warming and the response of glaciers and polar ice sheets. Complex processes control the discharges from polar ice sheets and some are already producing substantial additions of water to the ocean.[554] Because these processes are not well understood, it is difficult to predict their future contributions to sea-level rise.[90,555]

As discussed in the *Global Climate Change* section, recent estimates of global sea-level rise substantially exceed the IPCC estimates, suggesting sea-level rise between 3 and 4 feet in this century. Even a 2-foot rise in relative sea level over a century would result in the loss of a large portion of the nation's remaining coastal wetlands, as they are not able to build new soil at a fast enough rate.[164] Accelerated sea-level rise would affect seagrasses, coral reefs, and other important habitats. It would also fragment barrier islands, and place into jeopardy existing homes, businesses, and infrastructure, including roads, ports, and water and sewage systems. Portions of major cities, including Boston and New York, would be subject to inundation by ocean water during storm surges or even during regular high tides.[234]

More spring runoff and warmer coastal waters will increase the seasonal reduction in oxygen resulting from excess nitrogen from agriculture.

Coastal dead zones in places such as the northern Gulf of Mexico[556] and the Chesapeake Bay[557] are likely to increase in size and intensity as warming increases unless efforts to control runoff of agricultural fertilizers are redoubled. Greater spring runoff into East Coast estuaries and the Gulf of Mexico would flush more nitrogen into coastal waters stimulating harmful blooms of algae and the excess production of microscopic plants that settle near the seafloor and deplete oxygen supplies as they decompose. In addition, all else being equal, greater runoff reduces salinity, which when coupled with warmer surface water increases the difference in density between surface and bottom waters, thus preventing the replacement of oxygen in the deeper waters. As dissolved oxygen levels decline below a certain level, living things cannot survive. They leave the area if they can, and die if they cannot.

Dead Zones in the Chesapeake Bay



Wicks et al.[558]

Climate change is likely to expand and intensify "dead zones," areas where bottom water is depleted of dissolved oxygen because of nitrogen pollution, threatening living things.

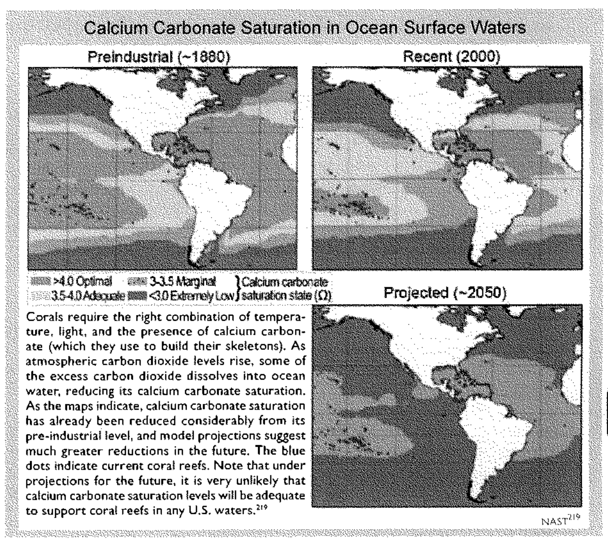
Coastal waters are very likely to continue to warm by as much 4 to 8°F in this century, both in summer and winter.[234] This will result in a northward shift in the geographic distribution of marine life along the coasts; this is already being observed.[70,347] The shift occurs because some species cannot tolerate the higher temperatures and others are out-competed by species from farther south moving in.[270] Warming also opens the door to invasion by species that humans are intentionally or unintentionally transporting around the world, for example in the ballast water carried by ships. Species that were previously unable to establish populations because of cold winters are likely to find the warmer conditions more welcoming and gain a foothold,[567] particularly as native species are under stress from climate change and other human activities. Non-native clams and small crustaceans have already had major effects on the San Francisco Bay ecosystem and the health of its fishery resources.[559]

Higher water temperatures and ocean acidification due to increasing atmospheric carbon dioxide will present major additional stresses to coral reefs, resulting in significant die-offs and limited recovery.

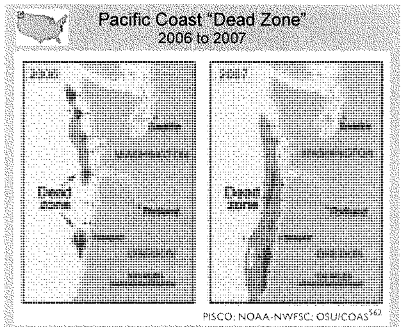
In addition to carbon dioxide's heat-trapping effect, the increase in its concentration in the atmosphere is gradually acidifying the ocean. About one-third of the carbon dioxide emitted by human activities has been absorbed by the ocean, resulting in a decrease in the ocean's pH. Since the beginning of the industrial era, ocean pH has declined demonstrably and is projected to decline much more by 2100 if current emissions trends continue. Further declines in pH are very likely to continue to affect the ability of living things to create and maintain shells or skeletons of calcium carbonate. This is because at a lower pH less of the dissolved carbon is available as carbonate ions (see *Global Climate Change*).[70,259]

Ocean acidification will affect living things including important plankton species in the open ocean, mollusks and other shellfish, and corals.[22,23,70,259] The effects on reef-building corals are likely to be particularly severe during this century. Coral calcification rates are likely to decline by more than 30 percent under a doubling of atmospheric carbon dioxide concentrations, with erosion outpacing reef formation at even lower concentrations.[22] In addition, the reduction in pH also affects photosynthesis, growth, and reproduction. The upwelling of deeper ocean water, deficient in carbonate, and thus potentially detrimental to the food chains supporting juvenile salmon has recently been observed along the U.S. West Coast.[259]

Acidification imposes yet another stress on reef-building corals, which are also subject to bleaching – the expulsion of the microscopic algae that live inside the corals



Corals require the right combination of temperature, light, and the presence of calcium carbonate (which they use to build their skeletons). As atmospheric carbon dioxide levels rise, some of the excess carbon dioxide dissolves into ocean water, reducing its calcium carbonate saturation. As the maps indicate, calcium carbonate saturation has already been reduced considerably from its pre-industrial level, and model projections suggest much greater reductions in the future. The blue dots indicate current coral reefs. Note that under projections for the future, it is very unlikely that calcium carbonate saturation levels will be adequate to support coral reefs in any U.S. waters.[219]



PISCO; NOAA-NWFSC; OSU/COAS[562]

Climate change affects coastal currents that moderate ocean temperatures and the productivity of ecosystems. As such, it is believed to be a factor in the low-oxygen "dead zone" that has appeared along the coast of Washington and Oregon in recent years.[561] In the maps above, blue indicates low-oxygen areas and purple shows areas that are the most severely oxygen depleted.

and are essential to their survival – as a result of heat stress[70] (see *Ecosystems* sector and *Islands* region). As a result of these and other stresses, the corals that form the reefs in the Florida Keys, Puerto Rico, Hawaii, and the Pacific Islands are projected to be lost if carbon dioxide concentrations continue to rise at their current rate.[560]

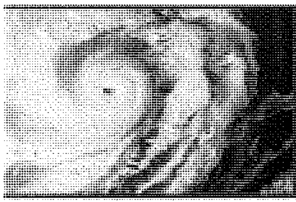
Changing ocean currents will affect coastal ecosystems.

Because it affects the distribution of heat in the atmosphere and the oceans, climate change will affect winds and currents that move along the nation's coasts, such as the California Current that bathes the West Coast from British Columbia to Baja California.[70] In this area, wind-driven upwelling of deeper ocean water along the coast is vital to moderation of temperatures and the high productivity of Pacific Coast ecosystems. Coastal currents are subject to periodic variations caused by the El Niño-Southern Oscillation and the Pacific Decadal Oscillation, which have substantial effects on the success of salmon and other fishery resources. Climate change is expected to affect such coastal currents, and possibly the larger scale natural oscillations as well, though these effects are not yet well understood. The recent emergence of oxygen-depletion events on the continental shelf off Oregon and Washington (a dead zone not directly caused by agricultural runoff and waste discharges such as those in the Gulf of Mexico or Chesapeake Bay) is one example.[561]

Adaptation: Coping with Sea-Level Rise

Adaptation to sea-level rise is already taking place in three main categories: (1) protecting the coastline by building hard structures such as levees and seawalls (although hard structures can, in some cases, actually increase risks and worsen beach erosion and wetland retreat), (2) accommodating rising water by elevating or redesigning structures, enhancing wetlands, or adding sand from elsewhere to beaches (the latter is not a permanent solution, and can encourage development in vulnerable locations), and (3) planned retreat from the coastline as sea level rises.

Several states have laws or regulations that require setbacks for construction based on the planned life of the development and observed erosion rates. North Carolina, Rhode Island, and South Carolina are using such a moving baseline to guide planning. Maine's Coastal Sand Dune Rules prohibit buildings of a certain size that are unlikely to remain stable with a sea-level rise of 2 feet. The Massachusetts Coastal Hazards Commission is preparing a 20-year infrastructure and protection plan to improve hazards management and the Maryland Commission on Climate Change has recently made comprehensive recommendations to reduce the state's vulnerability to sea-level rise and coastal storms by addressing building codes, public infrastructure, zoning, and emergency preparedness. Governments and private interests are beginning to take sea-level rise into account in planning levees and bridges, and in the siting and design of facilities such as sewage treatment plants (see Adaptation box in Northeast region).



An Agenda for Climate Impacts Science

Both mitigation and adaptation decisions are becoming increasingly necessary. Advancing our knowledge in the many aspects of science that affect the climate system has already contributed greatly to decision making on climate change issues. Further advances in climate science including better understanding and projections regarding rainfall, storm tracks, storm intensity, heat waves, and sea-level rise will improve decision making capabilities.

The focus below, however, is on advancing our knowledge specifically on climate change impacts and those aspects of climate change responsible for these impacts in order to continue to guide decision making.

Recommendation 1: Expand our understanding of climate change impacts.

There is a clear need to increase understanding of how ecosystems, social and economic systems, human health, and infrastructure will be affected by climate change in the context of other stresses. New understanding will come from a mix of activities including sustained and systematic observations, field and laboratory experiments, model development, and integrated impact assessments. These will incorporate shared learning among researchers, practitioners (such as engineers and water managers), and local stakeholders.

Ecosystems

Ecosystem changes, in response to changes in climate and other environmental conditions, have already been documented. These include changes in the chemistry of the atmosphere and precipitation, vegetation patterns, growing season length, plant productivity, animal species distributions, and the frequency and severity of pest outbreaks and fires. In the marine environment, changes include the health of corals and other living things due to temperature stress and ocean acidification. These observations not only document climate-change impacts, but also provide critical input to understanding how and why these changes occur, and how changes in ecosystems in turn affect climate. In this way, records of observed changes can improve projections of future impacts related to various climate change scenarios.

In addition to observations, large-scale, whole-ecosystem experiments are essential for improving projections of impacts. Ecosystem-level experiments that vary multiple factors, such as temperature, moisture, ground-level ozone, and atmospheric carbon dioxide, would provide process-level understanding of the ways ecosystems could respond to climate change in the context of other environmental stresses. Such experiments are particularly important for ecosystems with the greatest potential to experience massive change due to the crossing of thresholds or tipping points.

Insights regarding ecosystem responses to climate change gained from both observations and experiments are the essential building blocks of ecosystem simulation models. These models, when rigorously developed and tested, provide powerful tools for exploring the ecosystem consequences of alternative future climates. The incorporation of ecosystem models into an integrated assessment framework that includes socioeconomic, atmospheric and ocean chemistry, and atmosphere-ocean general circulation models should be a major goal of impacts research. This knowledge can provide a base for research studies into ways to manage critical ecosystems in an environment that is continually changing.

Economic systems, human health, and the built environment

As natural systems experience variations due to a changing climate, social and economic systems will be affected. Food production, water resources, forests, parks, and other managed systems provide life support for society. Their sustainability will depend on how well they can adapt to a future climate that is different from historical experience.

At the same time, climate change is exposing human health and the built environment to increasing risks. Among the likely impacts are an expansion of the ranges of insects and other animals that carry diseases and a greater incidence of health-threatening air pollution events compounded by unusually hot weather associated with climate change. In coastal areas, sea-level rise and storm surge threaten infrastructure including homes, roads, ports, and oil and gas drilling and distribution facilities. In other parts of the country, floods, droughts, and other weather and climate extremes pose increasing threats.

Careful observations along with climate and Earth system models run with a range of emissions scenarios can help society evaluate these risks and plan actions to minimize them. Work in this area would include assessments of the performance of delivery systems, such as those for regional water and electricity supply, so that climate change impacts and costs can be evaluated in terms of changes in risk to system performance. It will be particularly important to understand when the effects on these systems are extremely large and/or rapid, similar to tipping points and thresholds in ecosystems.

In addition, the climate change experienced outside the United States will have implications for our nation. A better understanding of these international linkages, including those related to trade, security, and large-scale movements of people in response to climate change, is desirable.

Recommendation 2:
Refine ability to project climate change, including extreme events, at local scales.

One of the main messages to emerge from the past decade of synthesis and assessments is that while climate change is a global issue, it has a great deal of regional variability. There is an indisputable need to improve understanding of climate system effects at these smaller scales, because these are often the scales of decision making in society. Understanding impacts at local scales will also help to target finite resources for adaptation measures. Although much progress has been made in understanding important aspects of this variability, uncertainties remain. Further work is needed on how to quantify cumulative uncertainties across spatial scales and the uncertainties associated with complex, intertwined natural and social systems.

Because region-specific climate changes will occur in the context of other environmental and social changes that are also region-specific, it is important to continue to refine our understanding of regional details, especially those related to precipitation and soil moisture. This would be aided by further testing of models against observations using established metrics designed to evaluate and improve the realism of regional model simulations.

Continued development of improved, higher resolution global climate models, increased computational capacity, extensive climate model experiments, and improved downscaling methods will increase the value of geographically specific climate projections for decision makers in government, business, and the general population.

Extreme weather and climate events are a key component of regional climate. Additional attention needs to be focused on improved observations (made on the relevant time and space scales to capture high-impact extreme events) and associated research and analysis of the potential for future changes in extremes. Impacts analyses indicate that extreme weather and climate events often play a major role in determining climate-change consequences.

Recommendation 3:
Expand capacity to provide decision makers and the public with relevant information on climate change and its impacts.

The United States has tremendous potential to create more comprehensive measurement, archive, and data-access systems and to convey needed information that could provide great benefit to society. There are several aspects to fulfilling this goal: defining what is most relevant, gathering the needed information, expanding the capacity to deliver information, and improving the tools for decision makers to use this information to the best advantage. All of these aspects should involve an interactive and iterative process of continual learning between those who provide information and those who use it. Through such a process, monitoring systems, distribution networks, and tools for using information can all be refined to meet user needs.

For example, tools used by researchers that could also be useful to decision makers include those that analyze and display the probability of occurrence of a range of outcomes to help in assessing risks.

Improved climate monitoring can be efficiently achieved by following the Climate Monitoring Principles recommended by the National Academy of Sciences and the Climate Change Science Strategic Plan in addition to integrating current efforts of governments at all levels. Such a strategy complements a long-term commitment to the measurement of the set of essential climate variables identified by both the Climate Change Science Program and the Global Climate Observing System. Attention must be placed on the variety of time and space scales critical for decision making.

Improved impacts monitoring would include information on the physical and economic effects of extreme events (such as floods and droughts), available, for example, from emergency preparedness and resource management authorities. It would also include regular archiving of information about impacts.

Improved access to data and information archives could substantially enhance society's ability to respond to climate change. While many data related to climate impacts are already freely and readily available to a broad range of users, other data, such as damage costs, are not, and efforts should be made to make them available. Easily accessible information should include a set of agreed-upon baseline indicators and measures of environmental conditions that can be used to track the effects of changes in climate. Services that provide reliable, well-documented, and easily used climate information, and make this information available to support users, are important.

Recommendation 4:
Improve understanding of thresholds likely to lead to abrupt changes in climate or ecosystems.

Paleoclimatic data show that climate can and has changed quite abruptly when certain thresholds are crossed. Similarly, there is evidence that ecological and human systems can undergo abrupt change when tipping points are reached.

Within the climate system there are a number of key risks to society for which understanding is still quite limited. Additional research is needed in some key areas, for example, identifying thresholds that lead to rapid changes in ice sheet dynamics. Sea-level rise is a major concern and improved understanding of the sensitivity of the major ice sheets to sustained warming requires improved observing capability, analysis, and modeling of the ice sheets and their interactions with nearby oceans. Estimates of sea-level rise in previous assessments, such as the recent Intergovernmental Panel on Climate Change 2007 report, did not fully quantify the magnitude and rate of future sea-level rise due to inadequate scientific understanding of potential instabilities of the Greenland and Antarctic ice sheets.

Tipping points in biological systems include the temperature thresholds above which insects survive winter, and can complete two life cycles instead of one in a single growing season, contributing to infestations that kill large numbers of trees. The devastation caused by bark beetles in Canada, and increasingly in the U.S. West, provides an example of how crossing such a threshold can set off massive destruction in an ecosystem with far-reaching consequences.

Similarly, there is increasing concern about the acidification of the world's oceans due to rising atmospheric carbon dioxide levels. There are ocean acidity thresholds beyond which corals and other living things, including some that form the base of important marine food chains, will no longer be able to form the shells and other body structures they need to survive. Improving understanding of such thresholds is an important goal for future research.

Recommendation 5: Improve understanding of the most effective ways to reduce the rate and magnitude of climate change, as well as unintended consequences of such activities.

This report underscores the importance of reducing the concentrations of heat-trapping gases in the atmosphere. Impacts of climate change during this century and beyond are projected to be far larger and more rapid in scenarios in which greenhouse gas concentrations continue to grow rapidly compared to scenarios in which concentrations grow more slowly. Additional research will help identify the desired mix of mitigation options necessary to control the rate and magnitude of climate change.

In addition to their intended reduction of atmospheric concentrations of greenhouse gases, mitigation options also have the potential for unintended consequences, which should also be examined in future research. For example, the production, transportation, and use of biofuels could lead to increases in water and fertilizer use as well as in some air pollutants. It could also create competition among land uses for food production, biofuels production, and natural ecosystems that provide many benefits to society. Improved understanding of such unintended consequences, and identification of those options that carry the largest negative impacts, can help decision makers make more informed choices regarding the possible trade-offs inherent in various mitigation strategies.

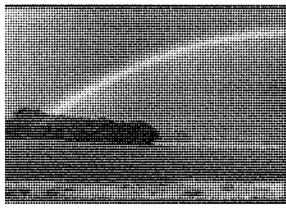
Recommendation 6: Enhance understanding of how society can adapt to climate change.

There is currently limited knowledge about the ability of communities, regions, and sectors to adapt to future climate change. It is important to improve understanding of how to enhance society's capacity to adapt to a changing climate in the context of other environmental stresses. Interdisciplinary research on adaptation that takes into account the interconnectedness of the Earth system and the complex nature of the social, political, and economic environment in which adaptation decisions must be made would be central to this effort.

The potential exists to provide insights into the possible effectiveness and limits of adaptation options that might be considered in the future. To realize this potential, new research would be helpful to document past responses to climate variability and other environmental changes, analyze the underlying reasons for them, and explain how individual and institutional decisions were made. However, human-induced climate change is projected to be larger and more rapid than any experienced by modern society so there are limits to what can be learned from the past.

A major difficulty in the analysis of adaptation strategies in this report has been the lack of information about the potential costs of adaptation measures, their effectiveness under various scenarios of climate change, the time horizons required for their implementation, and unintended consequences. These types of information should be systematically gathered and shared with decision makers as they consider a range of adaptation options. It is also clear that there is a substantial gap between the available information about climate change and the development of new guidelines for infrastructure such as housing, transportation, water systems, commercial buildings, and energy systems. There are also social and institutional obstacles to appropriate action, even in the face of adequate knowledge. These obstacles need to be better understood so that they can be reduced or eliminated.

Finally, it is important to carry out regular assessments of adaptation measures that address combined scenarios of future climate change, population growth, and economic development paths. This is an important opportunity for shared learning in which researchers, practitioners, and stakeholders collaborate using observations, models, and dialogue to explore adaptation as part of long-term, sustainable development planning.



Concluding Thoughts

Responding to changing conditions

Human-induced climate change is happening now, and impacts are already apparent. Greater impacts are projected, particularly if heat-trapping gas emissions continue unabated. Previous assessments have established these facts, and this report confirms, solidifies, and extends these conclusions for the United States. It reports the latest understanding of how climate change is already affecting important sectors and regions. In particular, it reports that some climate change impacts appear to be increasing faster than previous assessments had suggested. This report represents a significant update to previous work, as it draws from the U.S. Climate Change Science Program's Synthesis and Assessment Products and other recent studies that examine how climate change and its effects are projected to continue to increase over this century and beyond.

Climate choices

Choices about emissions now and in the coming years will have far-reaching consequences for climate change impacts. A consistent finding of this assessment is that the rate and magnitude of future climate change and resulting impacts depend critically on the level of global atmospheric heat-trapping gas concentrations as well as the types and concentrations of atmospheric particles (aerosols). Lower emissions of heat-trapping gases will delay the appearance of climate change impacts and lessen their magnitude. Unless the rate of emissions is substantially reduced, impacts are expected to become increasingly severe for more people and places.

Similarly, there are choices to be made about adaptation strategies that can help to reduce or avoid some of the undesirable impacts of climate change. There is much to learn about the effectiveness of the various types of adaptation responses and how they will interact with each other and with mitigation actions.

Responses to the climate change challenge will almost certainly evolve over time as society learns by doing. Determining and refining societal responses will be an iterative process involving scientists, policymakers, and public and private decision makers at all levels. Implementing these response strategies will require careful planning and continual feedback on the impacts of mitigation and adaptation policies for government, industry, and society.

The value of assessments

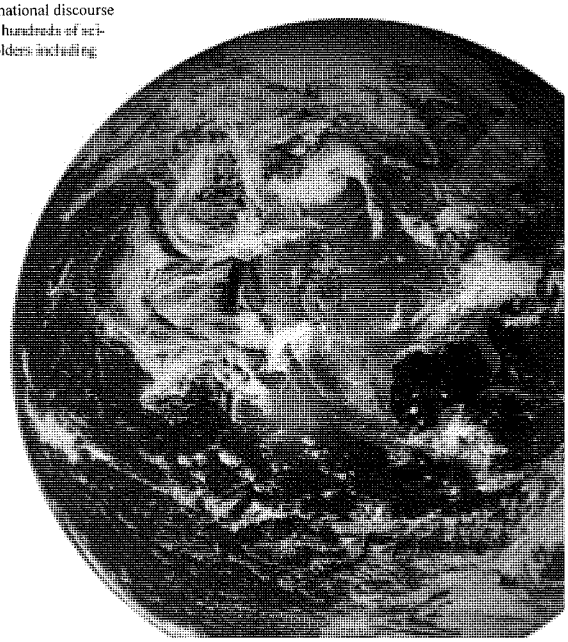
Science has revolutionized our ability to observe and model the Earth's climate and living systems, to understand how they are changing, and to project future changes in ways that were not possible in prior generations. These advances have enabled the assessment of climate change, impacts, vulnerabilities, and response strategies. Assessments serve a very important function in providing the scientific underpinnings of informed policy. They can identify advances in the underlying science, provide critical analysis of issues, and highlight key findings and key unknowns that can guide decision making. Regular assessments also serve as progress reports to evaluate and improve policy making and other types of decision making related to climate change.

Impacts and adaptation research includes complex human dimensions, such as economics, management, governance, behavior, and equity. Comprehensive assessments provide an opportunity to evaluate the social implications of climate change within the context of larger questions of how communities and the nation as a whole create sustainable and environmentally sound development paths.

A vision for future U.S. assessments

Over the past decade, U.S. federal agencies have undertaken two coordinated, national-scale efforts to evaluate the impacts of global climate change on this country. Each effort produced a report to the nation – *Climate Change Impacts on the United States*, published in 2000, and this report, *Global Climate Change Impacts in the United States*, published in 2009. A unique feature of the first report was that in addition to reporting the current state of the science, it created a national discourse on climate change that involved hundreds of scientists and thousands of stakeholders including farmers, ranchers, resource managers, city planners, business people, and local and regional government officials. A notable feature of the second report is the incorporation of information from the 21 topic-specific Synthesis and Assessment Products, many motivated by stakeholder interactions.

A vision for future climate change assessments includes both sustained, extensive stakeholder involvement, and targeted, scientifically rigorous reports that address concerns in a timely fashion. The value of stakeholder involvement includes helping scientists understand what information society wants and needs. In addition, the problem-solving abilities of stakeholders will be essential to designing, initiating, and evaluating mitigation and adaptation strategies and their interactions. The best decisions about these strategies will come when there is widespread understanding of the complex issue of climate change – the science and its many implications for our nation.



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PRIMARY SOURCES OF INFORMATION

CCSP Goal 1: Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and change.	
CCSP	*Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences*
	Thomas R. Karl, NOAA; Susan J. Hassol, STG Inc.; Christopher D. Miller, NOAA; William L. Murray, STG Inc.
CCSP	*Past Climate Variability and Change in the Arctic and at High Latitudes*
Past Climate	Richard B. Alley, Pennsylvania State Univ.; Julie Brigham-Grette, Univ. of Massachusetts; Gifford H. Miller, Univ. of Colorado; Leonid Polyak, Ohio State Univ.; James W.C. White, Univ. of Colorado; Joan J. Fitzpatrick, USGS
CCSP	*Re-Analysis of Historical Climate Data for Key Atmospheric Features: Implications for Attribution of Causes of Observed Change*
	Randall M. Dole, Martin P. Hoerling, Siegfried Schubert, NOAA
CCSP Goal 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems.	
	Part A: *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations* Part B: *Global-Change Scenarios: Their Development and Use*
GHG Emissions	Leon E. Clarke, James A. Edmonds, Hugh M. Pitcher, Pacific Northwest National Lab.; Henry D. Jacoby, MIT; John M. Reilly, MIT; Richard G. Richels, Electric Power Research Institute; Edward A. Parson, Univ. of Michigan; Virginia R. Burkett, USGS; Karen Fisher-Vanden, Dartmouth College; David W. Keith, Univ. of Calgary; Linda O. Mearns, NCAR; Cynthia E. Rosenzweig, NASA; Mort D. Webster, MIT; John C. Houghton DOE/Office of Biological and Environmental Research
	The First State of the Carbon Cycle Report (SOCCR) North American Carbon Budget and Implications for the Global Carbon Cycle
Carbon Cycle	Anthony W. King, ORNL; Lisa Dilling, Univ. of Colorado/NCAR; Gregory P. Zimmerman, ORNL; David Fairman, Consensus Building Institute Inc.; Richard A. Houghton, Woods Hole Research Center; Gregg Marland, ORNL; Adam Z. Rose, Pennsylvania State Univ. and Univ. Southern California; Thomas J. Wilbanks, ORNL
	Atmospheric Aerosol Properties and Climate Impacts
	Mian Chin, NASA; Ralph A. Kahn, NASA; Stephen E. Schwartz, DOE/BNL; Lorraine A. Remer, NASA/GSFC; Hongbin Yu, NASA/GSFC/UMBC; David Rind, NASA/GISS; Graham Feingold, NOAA/ESRL; Patricia K. Quinn, NOAA/PMEL; David G. Streets, DOE/ANL; Philip DeCola, NASA HQ; Ranganayi Halthore, NASA HQ/NRL
	Trends in Emissions of Ozone-Depleting Substances, Ozone Layer Recovery, & Implications for Ultraviolet Radiation Exposure
	A.R. Ravishankara, NOAA; Michael J. Kurylo, NASA; Christine Ennis, NOAA/ESRL

CCSP Goal 3: Reduce uncertainty in projections of how the Earth's climate and related systems may change in the future	
Climate Models: An Assessment of Strengths and Limitations	David C. Bader and Curt Covey, Lawrence Livermore National Lab.; William J. Gutowski Jr., Iowa State Univ.; Isaac M. Held, NOAA/GFDL; Kenneth E. Kunkel, Illinois State Water Survey; Ronald L. Miller, NASA/GISS; Robin T. Tokmakian, Naval Postgraduate School; Minghua H. Zhang, State Univ. of New York Stony Brook; Anjuli S. Bamzai, U.S. DOE
Climate Projections Based on Emissions Scenarios for Long-Lived and Short-Lived Radiatively Active Gases and Aerosols	Hiram Levy II, NOAA/GFDL; Drew Shindell, NASA/GISS; Alice Gilliland, NOAA/ARL; M. Daniel Schwarzkopf, NOAA/GFDL; Larry W. Horowitz, NOAA/GFDL; Anne M. Waple, STG Inc.
Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands	Thomas R. Karl, NOAA; Gerald A. Meehl, NCAR; Christopher D. Miller, NOAA; Susan J. Hassol, STG Inc.; Anne M. Waple, STG Inc.; William L. Murray, STG Inc.
Abrupt Climate Change	John P. McGeehin, USGS; John A. Barron, USGS; David M. Anderson, NOAA; David J. Verardo, NSF; Peter U. Clark, Oregon State Univ.; Andrew J. Weaver, Univ. of Victoria; Konrad Steffen, Univ. of Colorado; Edward R. Cook, Columbia Univ.; Thomas L. Delworth, NOAA; Edward Brook, Oregon State Univ.
CCSP Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes	
Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region	James G. Titus, U.S. EPA; K. Eric Anderson, USGS; Donald R. Cahoon, USGS; Dean B. Gesch, USGS; Stephen K. Gill, NOAA; Benjamin T. Gutierrez, USGS; E. Robert Thieler, USGS; S. Jeffress Williams, USGS
Thresholds of Climate Change in Ecosystems	Daniel B. Fagre, USGS; Colleen W. Charles, USGS
The Effects of Climate Change on Agriculture, Land Resources, Water Resources and Biodiversity in the United States	Peter Backlund, NCAR; Anthony Janetos, PNNL/Univ. of Maryland; David Schimel, National Ecological Observatory Network; Margaret Walsh, USDA
Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources	Susan Herrod Julius, U.S. EPA; Jordan M. West, U.S. EPA; Jill S. Baron, USGS and Colorado State Univ.; Linda A. Joyce, USDA Forest Service; Brad Griffith, USGS; Peter Kareiva, The Nature Conservancy; Brian D. Keller, NOAA; Margaret Palmer, Univ. of Maryland; Charles Peterson, Univ. of North Carolina; J. Michael Scott, USGS and Univ. of Idaho
Effects of Climate Change on Energy Production and Use in the United States	Thomas J. Wilbanks, ORNL; Vatsal Bhatt, Brookhaven National Lab.; Daniel E. Bilello, National Renewable Energy Lab.; Stanley R. Bull, National Renewable Energy Lab.; James Ekmann, National Energy Technology Lab.; William C. Horak, Brookhaven National Lab.; Y. Joe Huang, Mark D. Levine, Lawrence Berkeley National Lab.; Michael J. Sale, ORNL; David K. Schmalzer, Argonne National Lab.; Michael J. Scott, Pacific Northwest National Lab.

Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems	
Janet L. Gamble, U.S. EPA; Kristie L. Ebi, ESS LLC.; Anne E. Grambsch, U.S. EPA; Frances G. Sussman, Environmental Economics Consulting; Thomas J. Wilbanks, ORNL	
Impacts of Climate Variability and Change on Transportation Systems and Infrastructure – Gulf Coast Study	
Michael J. Savonis, Federal Highway Administration; Virginia R. Burkett, USGS; Joanne R. Potter, Cambridge Systematics	
CCSP Goal 5: [illegible]	
Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions	
John Haynes, NASA; Fred Vukovich, SAIC; Molly K. Macauley, RFF; Dawson W. Byun, Univ. of Houston; David Renne, NREL; Gregory Glass, Johns Hopkins School of Public Health; Holly Hartmann, Univ. of Arizona	
Best Practice Approaches for Characterizing, Communicating and Incorporating Scientific Uncertainty in Climate Decision Making	
M. Granger Morgan, Dept. of Engineering and Public Policy, Carnegie Mellon Univ.; Hadi Dowlatabadi, Inst. for Resources, Environment and Sustainability, Univ. of British Columbia; Max Henrion, Lumina Decision Systems; David Keith, Dept. of Chemical and Petroleum Engineering and Dept. of Economics, Univ. of Calgary; Robert Lempert, The RAND Corp.; Sandra McBride, Duke Univ.; Mitchell Small, Dept. of Engineering and Public Policy, Carnegie Mellon Univ.; Thomas Wilbanks, Environmental Science Division, ORNL	
Decision Support Experiments and Evaluations using Seasonal-to-Interannual Forecasts and Observational Data: A Focus on Water Resources	
Nancy Beller-Simms, NOAA; Helen Ingram, Univ. of Arizona; David Feldman, Univ. of California; Nathan Mantua, Climate Impacts Group, Univ. of Washington; Katharine L. Jacobs, Arizona Water Institute; Anne M. Waple, STG Inc.	
Other Assessments Referenced	
WG-1	Working Group I - *Climate Change 2007: The Physical Science Basis*
	Susan Solomon, Dahe Qin, Martin Manning, Zhenlin Chen, Melinda Marquis, Kristen B. Averyt, Melinda M.B. Tignor, Henry LeRoy Miller, Jr.
WG-2	Working Group II - *Climate Change 2007: Impacts, Adaptation and Vulnerability*
	Martin L. Parry, Osvaldo F. Canziani, Jean P. Palutikof, Paul J. van der Linden, Clair E. Hanson
WG-3	Working Group III - *Climate Change 2007: Mitigation of Climate Change*
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Potential Impacts of Climate Change on U.S. Transportation	
Henry G. Schwartz, Jr., Alan C. Clark, G. Edward Dickey, George C. Eads, Robert E. Gallamore, Genevieve Giuliano, William J. Gutowski, Jr., Randell H. Iwasaki, Klaus H. Jacob, Thomas R. Karl, Robert J. Lempert, Luisa M. Paiewonsky, S. George H. Philander, Christopher R. Zeppie	
Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change	
Jerry M. Melillo, Anthony C. Janetos, Thomas R. Karl, Eric J. Barron, Virginia Rose Burkett, Thomas F. Cecich, Robert W. Corell, Katharine L. Jacobs, Linda A. Joyce, Barbara Miller, M. Granger Morgan, Edward A. Parson, Richard G. Richels, David S. Schimel	
Impacts of a Warming Arctic: Arctic Climate Impact Assessment	
Robert W. Corell, Susan J. Hassol, Pål Prestrud, Patricia A. Anderson, Snorri Baldursson, Elizabeth Bush, Terry V. Callaghan, Paul Grabhorn, Gordon McBean, Michael MacCracken, Lars-Otto Reiersen, Jan Idar Solbakken, Gunter Weller	

ACRONYMS AND ABBREVIATIONS

ARS: Agricultural Research Service
CCSP: Climate Change Science Program
CIESIN: Center for International Earth Science Information Network
CIRES: Cooperative Institute for Research in Environmental Sciences
CMIP: Coupled Model Intercomparison Project
DOE: Department of Energy
EIA: Energy Information Administration
IARC: International Arctic Research Center
IPCC: Intergovernmental Panel on Climate Change
NASA: National Aeronautics and Space Administration
NASS: National Agricultural Statistics Service
NAST: National Assessment Synthesis Team
NCDC: National Climatic Data Center
NESDIS: National Environmental Satellite, Data, and Information Service
NOAA: National Oceanic and Atmospheric Administration
NRCS: Natural Resources Conservation Service
NSIDC: National Snow and Ice Data Center
NWS: National Weather Service
NWFSC: Northwest Fisheries Science Center
PISCO: Partnership for Interdisciplinary Studies of Coastal Oceans
PLJV: Playa Lakes Joint Venture
SAP: Synthesis and Assessment Product
SRH: Southern Regional Headquarters
USACE: United States Army Corps of Engineers
USBR: States Bureau of Reclamation
USDA: United States Department of Agriculture
U.S. EPA: United States Environmental Protection Agency
USFS: United States Forest Service
USGS: United States Geological Survey

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U.S. time series on page 27 is calculated with data for the contiguous US, Alaska, and Hawaii. US map on page 28 lower left includes observed temperature change in Puerto Rico. Winter temperature trend map in the agriculture section, page 76, is for the contiguous US only.

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1. Heat waves:

   • The GHCN-Daily dataset from NCDC was used <http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/>

   • Data from 979 U.S. stations having long periods of record and high quality.

   • At each station, a day was considered hot if the maximum temperature for that day was at or above the 90% of daily maximum temperatures at that station.

2. Air stagnation:

• For each day in summer and at each air-stagnation grid point, it was determined if that location had stagnant air:

◦ The stagnation index was formulated by Wang, J.X.L. and J.K. Angell, 1999: *Air Stagnation Climatology for the United States (1948-1998)*. NOAA/Air Resources Laboratory atlas no.1 NOAA Air Resources Laboratory, Silver Spring, MD, 74 pp. <http://www.arl.noaa.gov/documents/reports/atlas.pdf>

◦ Operational implementation of this index is described at <http://www.ncdc.noaa.gov/oa/climate/research/stagnation/index.php>

Note: Although Wang and Angell used a criteria of four day stagnation periods, single stagnation days were used for this analysis.

3. For each location in the air stagnation grid, the nearest station (of the aforementioned 979 U.S. stations) was used to determine the coincidence of summer days having stagnant air and excessive heat as a percentage of the number of days having excessive heat.

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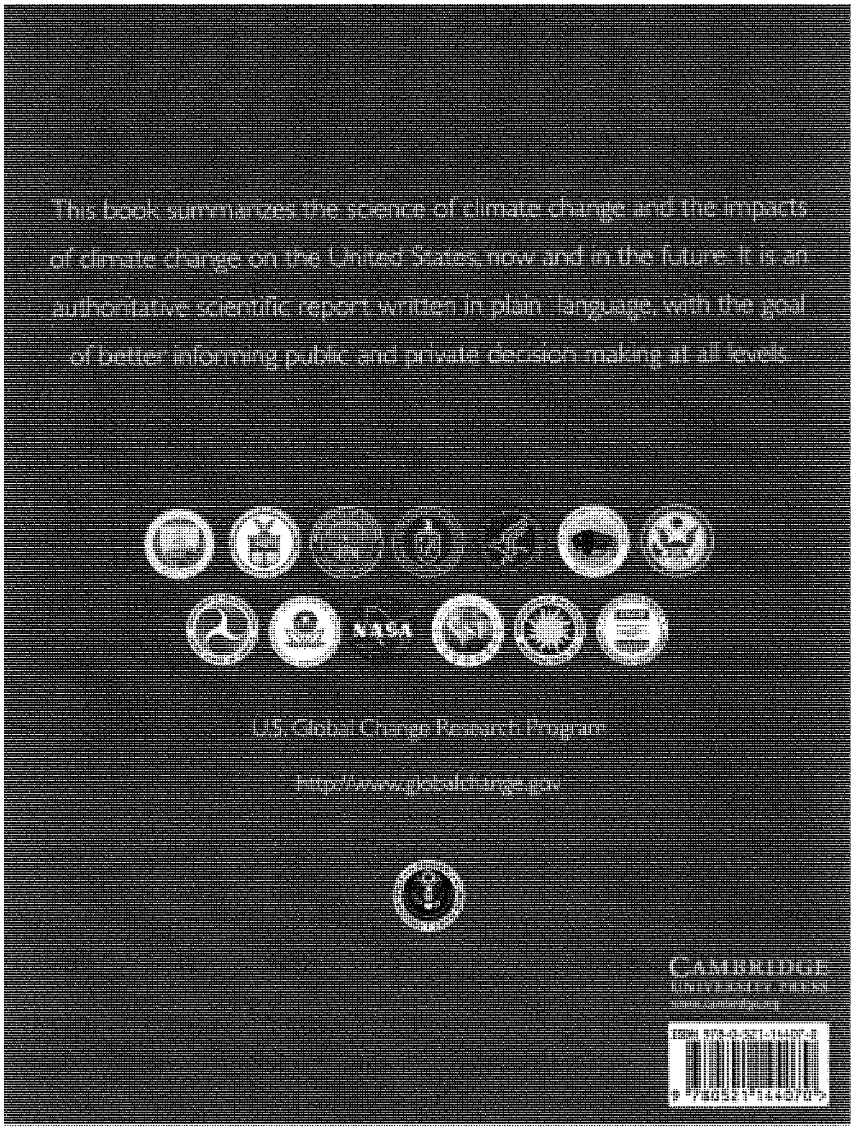
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Senator BOXER. And Senator Inhofe, you get some extra time.

Senator INHOFE. All right. Well, I could have used that yesterday.

Senator BOXER. I am sorry, we cannot go back to the future. If I could, I would.

Senator INHOFE. All right. Well, first of all, I would think that this bill would do nothing to address your concerns since it will result in no temperature changes because China and other developing nations refuse to accept binding emission targets to keep carbon below any amount.

But let us go ahead, since I am also in the Heartland and the Midwest, I would like to have both of you respond to this. Because I have seen the same charts. I have seen how we are going to be treated. Oklahoma is right between you guys. So, would you like to, can you help me understand why we still believe that our costs would be greater?

Well, first of all, let me say to you, Commissioner, I just left your Senator Thune, he said to say hello. And it is good to see you, Mr. Hart, over in Arkansas.

Mr. JOHNSON. Well, thank you very much, Senator.

I do want to make clear that regional disparities are some of the things that bother us the most. No one on this panel has argued for inaction. No one on this panel has said that carbon should not come with some price. The concerns that have been raised have been primarily around regional disparities. And I do think that is a big problem.

We start talking about a postage stamp a day, or we talk about $100 a year, those are national numbers. And I think they gloss over the very real, and the very problematic, regional disparities. You know, $5 for South Dakotans, I do not believe it. Most of that analysis has been done on flawed presumptions that the energy that is created in South Dakota is used in South Dakota. The Federal Government has not allowed us to do that. We have a lot of hydroelectric facilities in South Dakota and 80 percent of that power leaves the State.

And so, all of the numbers I have seen about South Dakota are based on some very, very flawed assumptions.

Senator INHOFE. Any comment, Mr. Hart?

Mr. HART. Senator, in Missouri, I mean that is why, because there are all these different studies, the people that live in Missouri wanted to know from the people generating kilowatt hours, whether it is wind farms, nuclear, natural gas, hydro, they want their professionals, the men and women generating kilowatt hours, to tell them, this is what it is going to cost us.

Now, the numbers I see under the different scenarios, one was $25 a ton for carbon, another one was $50 a ton for carbon. Various assumptions they made under different cases, but the rate increases, you are talking about 42 to 77 percent.

Senator INHOFE. The example you used this morning——

Mr. HART. Those are people that are generating kilowatt hours every day. And I guess the regional disparity is what the people that live in Missouri are keying in on, too. They are telling all of us that they do not understand why utilities in California get 100 percent allocation of emissions and Missouri gets 68.

Senator INHOFE. Yes. Let us keep in mind, too, that the costs that are going to be, now, if we are using the State of Missouri, we have heard your Senator, Kit Bond talk about how much it is going to cost the farmers. But there are other costs other than what we are talking about today. We are talking about the cost of fertilizer, the cost of all of things that affect, of course, we will have that panel tomorrow.

Let me ask you, Commissioner Johnson, you said in your statement, I am going to quote it here, the Chairman's mark includes a reserve fund with soft collar that this mechanism will not do enough to protect consumers. Could you explain that to me?

Mr. JOHNSON. I think the real concern you see in all of this modeling is when you get an allowance price that climbs up higher than what a lot of us plug in to our studies, $15 or $20. That is where I think the real fear comes in, Madam Chairman.

And I understand that. I think some people are looking for some level of confidence, that even if things get bad, consumers are not going to take the brunt of it, particularly Midwestern consumers.

And I understand what the reserve, the strategic reserve, is supposed to do. I read a number of economic analyses on it that indicate, perhaps, that it will not be as successful as we all hope that it will be. It seems to me that some sort of a hard collar would give us more confidence that, at the end of the day, the burden is not falling too squarely on the backs of Midwestern consumers.

Senator INHOFE. All right. Well, Commissioner, also, I do not recall just in what context you used that term a quarter of a billion dollars. Now what was that? Would you repeat that sentence for me?

Mr. JOHNSON. Almost every single load serving entity in South Dakota that has performed an analysis indicates that in the short term, utility prices would rise 25 percent in South Dakota.

We spend $1 billion a year on natural gas and electricity in South Dakota. I am not a mathematician, but I take $1 billion times 25 percent and I get $250 million a year.

I think that shows why talking about a postage stamp a day or $100 a year may make sense for our country. Maybe for the country the costs are reasonable. But there are regional disparities that essentially punish some parts of this country far more than they can afford to be punished.

Senator INHOFE. When you said that, I did not do the math because I figured you already had it. But you only have what, 800,000 people?

Mr. JOHNSON. We have only 800,000 people, just over 300,000 households and it ends up being a big ticket item.

Senator INHOFE. OK. So, you have done your math on the households, 300,000.

Mr. JOHNSON. It is $850 a year.

Senator INHOFE. Well see, this is the problem that we have, because we have seen these analyses way back to and including the treaty that this all started with 10 years ago, the Kyoto Treaty. And all the way through that, and through the 2003 bill, the McCain-Lieberman bill, the 2005 bill, the Warner-Lieberman bill in 2008, all of these analyses done by MIT, by all of these other groups, they come in the same consistent pattern. It does hit the

Heartland more, that the costs we are talking about is somewhere between $300 billion and $400 billion a year. And that is huge. And it affects different parts of the country in a different way.

Mr. Hart, you said in your opening statement, I wrote this down, you said that you have a 91 percent customer satisfaction rate. Are you proud of that?

Mr. HART. We are pretty proud of that.

Senator INHOFE. You should be.

Mr. HART. We do what our consumers tell us to do. They are supporting our wind development in the State. They like that we are going there.

Senator INHOFE. What do you think would happen to that 91 percent if you have this increase that we are talking about?

Mr. HART. I am not sure. I think it is going to go downward.

Senator INHOFE. Yes. I would think so.

Mr. HART. I think whatever policy is developed has got to have the support of the consumers. Whether you live in Missouri or Iowa or Arkansas or California or New York, we have got to get the people of this country, who love their country, to support the policy.

Here is another problem. This is tough pill for Missourians to swallow. The last power plant, base load power plant we built in Missouri came on line in 1983. I have done a lot of research on this. What was going in 1983? It was after the Arab oil embargo, our country was wanting us to get away from dependence on other countries. We could not generate electricity with gas because there was a Federal law that was passed that said you could not generate electricity with oil or gas.

We were going to build, our primary project that we wanted to build, was a nuclear project in the region. We had all the financing put together, we invested $80 million in site development, we submitted to the NRC, our members did. A week after we submitted the license, the moratorium was put on nuclear licensing. So now nuclear is not an option to our members.

This is 26 years ago. Our only option in Missouri was coal. And the Federal policy at that point in time, in the history of this country, was encouraging consumers to go with coal. And so now, 26 years later, for our consumers to feel like, because they live in Missouri they are going to be penalized, it is a tough pill to swallow.

Senator INHOFE. The problem is not are there other resources out there because, I have said in the last two panels, recently it has been documented that we are No. 1 in terms of our resources, our reserves in coal, gas and oil. It is a matter that 83 percent of that is off limits. As you point out, the moratoria are killing us. If we really want to wean ourselves off of foreign oil, let us go ahead and develop our resources that we have here.

Madam Chairman, my time has expired, but I have two letters for the record to submit. First is from the American Public Power Association, the association is represented here although not necessarily the whole association. The second is a statement from the Public Service Commission of North Dakota, outlining their concerns.

[The referenced information follows:]

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October 27, 2009

The Honorable Barbara Boxer Chairwoman Senate Environment and Public Works Committee SD-410 Dirksen Senate Office Building Washington, D.C. 20510	The Honorable James M. Inhofe Ranking Minority Member Senate Environment and Public Works Committee SD-410 Dirksen Senate Office Building Washington, D.C. 20510

Dear Chairwoman Boxer and Ranking Member Inhofe:

As your committee begins hearings this week and anticipates markup soon of S. 1733, the Clean Energy Jobs and American Power Act, I am writing on behalf of the American Public Power Association (APPA) to convey our views on the most recent version of the bill, the "Chairwoman's Mark" (Mark) released this past Saturday, October 24. APPA represents the interests of the more than 2,000 publicly-owned electric utilities nationwide, collectively serving over 45 million Americans. APPA supports federal legislation to reduce greenhouse gas (GHG) emissions, and we recognize the difficulty of addressing this issue in a comprehensive manner that achieves the desired environmental results while also protecting the American economy and consumers. With that recognition, we appreciate the hard work Chairwoman Boxer and her staff have invested in this issue in general and in the Mark in particular.

At the same time, based on our preliminary review of the Mark, we find that it falls short of what we believe is necessary for a workable, sustainable, and affordable GHG reduction program. Some of the changes made in the Mark, such as increased support for clean coal technologies and energy efficiency, are positive. However, we were disappointed to see that the key concerns we identified in the first iteration of S. 1733 remain essentially unchanged in the Mark.

This letter, then, summarizes our position on the issues of utmost priority for public power and to reiterate that appropriate resolution of these issues will be essential for APPA's support of any legislation.

S. 1733 must preempt the Clean Air Act. APPA believes that federal GHG emissions reduction legislation should create a new regime for addressing these ubiquitous gases that does not overlap or duplicate other existing environmental statutes, in order to avoid unnecessary confusion and litigation. Thus, provisions must be added to S. 1733 that makes it absolutely clear that the requirements and obligations of this new program are entirely separate from existing requirements under such statutes, particularly the Clean Air Aet.

S. 1733 must contain a hard "cost collar" or similar, equally effective cost containment mechanism. While we appreciate that S. 1733 improves the strategic reserve provisions of H.R. 2454, the Mark continues to only provide what has been dubbed a "soft" price collar, which is not really a collar at all because it is one-sided. The Mark merely sets the **minimum** price for the Market Stability Reserve created in the bill – which is $28, meaning the reserve will be activated only when the market price reaches $28 - but there is no limit on how high the reserve price can rise. APPA believes it preferable to enact a mechanism that also sets a hard maximum allowance price to ensure that energy costs do not rise too high and too fast, particularly for low-income consumers and energy-intensive industries.

S. 1733 must continue to freely allocate, and not auction, allowances to the electricity sector. APPA appreciates that the Mark allocates, rather than auctions, allowances to the electricity sector and we strongly urge you to continue that approach. Moreover, APPA supports extending the time frame for such allocations beyond 2030. One of the arguments advanced in favor of an auction is that the legislation should avoid giving industry a "windfall profit" at the expense of consumers. This concern arose from experiences with the European cap-and-trade system where many generators included the market cost of allowances in their electricity prices even though they were allocated allowances and did not pay for them. Allocating allowances to load-serving entities, rather than fossil fuel-fired generators, eliminates this concern (see below). Moreover, in the case of not-for-profit, consumer-owned public power utilities, we cannot reap a windfall or any other profit by definition.

S. 1733 must provide the electric utility sector with the amount of allowances necessary to operate under the bill's established targets and timelines without having to fuel switch. If enormous GHG reductions are required by the bill before the availability of new technology, such as carbon capture and sequestration (CCS), or the construction of new nuclear plants, the most likely result will be significant fuel-switching to natural gas and resulting higher natural gas prices. In addition to the risk of higher gas prices, significant switching to gas will increase GHG emissions (compared, for example, to a switch to nuclear or CCS), causing emissions to reach the cap sooner and increasing the market price for available allowances, which will in turn further increase the cost of electricity. Therefore, APPA urges the Committee to provide the electricity sector with enough allowances – approximately 40 percent of the total provided economy-wide - to cover existing operations at the beginning of the program with only modest reductions until technology such as CCS is commercially available on a wide scale in the U.S. Although S. 1733 seems to distribute 35% of allowances to the electricity sector, we are concerned that this is not really the case because it appears that Section 771 of the bill provides an initial reservation of allowances that takes precedence over all other auctioned or distributed allowances, such as those to electricity. Thus, it appears that the electricity sector would be receiving only 30% of the allowances, rather than the claimed 35 percent. This additional reduction to the electricity sector allowance pool is extremely problematic.

S. 1733 must only allocate allowances to local distribution companies (LDCs) and not to merchant coal generators. APPA urges the Committee to ensure that allocation of allowances flow directly to local distribution companies whose retail rates are regulated at the state and local levels as opposed to providing allowances to wholesale or "merchant" coal generators. A free allocation to merchant coal generators provides no price benefits. The generators will simply add the opportunity cost of holding an allowance to their price bids. Merchant coal generators primarily sell into the deregulated wholesale electricity markets administered by regional transmission organizations (RTOs). In these markets the highest bid sets the price each hour, meaning this opportunity cost adder raises the price of electricity sold by *all* plants in that hour –including renewable and nuclear generating units that emit no carbon. Unproductive costs, or the costs paid by consumers that are simply windfall profits and unrelated to carbon reductions, would increase greatly under an allocation to merchant coal. Unfortunately, S. 1733 includes the same allocation methodology as was included in H.R. 2454, which allows up to 10 percent of the total electricity sector allowances to flow to unregulated generators.

The targets and timelines in S. 1733 must be realistic. Instead of mentioning the exact year in which such emissions reductions should begin, APPA urges the Committee to consider establishing the timeline of "at least five years after date of enactment of the bill" before reductions begin thereby giving the regulatory process time to be completed and the technology more time to become commercially viable. In addition, the bill's aggressive emission targets may lead to short-sighted and expensive strategies to reduce CO_2 from the electric sector, such as a massive switch to natural-gas fired generation. APPA believes, with sufficient time and appropriate incentives for technology, we can reduce emissions and avoid unnecessary increases in electricity prices. The targets and timelines in S. 1733 do not allow for such a transition, and will impose an enormous cost on certain regions of the country unnecessarily.

Thank you for your consideration of our views.

Sincerely,

Mark Crisson

Mark Crisson
President and CEO

Cc: Members of the Senate Environment and Public Works Committee

Public Service Commission
State of North Dakota

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October 26, 2009

US Senate Committee on Environment & Public Works
456 Dirksen
Senate Office Building
Washington DC 20510-6175

RE: Written Testimony for Hearing on S. 1733 (Clean Energy Jobs and American Power Act)

This letter is intended to provide information about the effects of climate change legislation on North Dakota. A majority of this information was collected at the April 17 Carbon Cap and Trade Summit held in the North Dakota State Capitol.

Approximately 170 people attended the meeting, and representatives from North Dakota utility companies and cooperatives participated in a roundtable discussion where they made several recommendations regarding carbon regulation.

Enclosed is an executive summary that includes the details of the meeting and recommendations we respectfully ask you to consider as carbon legislation in Congress is being debated. In addition to the executive summary, you can also watch video of the entire presentation on our website, http://www.psc.state.nd.us/.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Tony Clark
Commissioner

Kevin Cramer
Chairman

Brian P. Kalk
Commissioner

North Dakota

Public Service Commission

Carbon Cap & Trade Summit – April 17, 2009
Executive Summary

INTRODUCTION

On April 17, 2009, the North Dakota Public Service Commission held a Carbon Cap & Trade Summit to discuss the impacts that carbon legislation currently being debated in Congress could have on North Dakota consumers and electric utilities. The meeting was held in the Brynhild Haugland Room of the State Capitol in Bismarck where approximately 170 people attended. The purpose of the meeting was to gather input from experts and utility company representatives on how carbon legislation will impact consumers and what should be done to minimize the negative impacts.

Because the Commission regulates investor-owned utilities and the rates they set, it is important for the agency to play a key role in the debate. And although the Commission does not regulate the rates of electric cooperatives, it recognizes that cooperatives and their members must be included in the discussion on carbon legislation. Adding to the importance of carbon regulation's impact on North Dakota is the fact that the state is a major energy producer that relies heavily on coal-based electricity generation, which is the main target of cap and trade legislation because it is the number one source of carbon dioxide emissions. In fact, 95 percent of North Dakota's electricity is generated from coal. Cap and trade in its simplest form, would place a limit on the amount of greenhouse gas emissions nationwide and assign a cost, similar to a tax, on those who need to emit them.

Although the discussion included some research and opinions about global climate change, the main focus was about how increases in costs brought on by cap and trade policies will result in utility companies charging higher rates to consumers. No one at the meeting doubted that cap and trade legislation will result in higher bills for residential, commercial and business customers. Input from representatives of utility companies indicated rates for North Dakota customers could increase significantly.

Cap and trade legislation has gained momentum in recent years, and especially this year with the inauguration of President Barack Obama, who has made it a major issue of his administration. Participants in the summit expressed concern that hastily drafted legislation could result in policies that are too costly and complicated to implement in a time when the economy faces a major economic downturn.

This report includes a summary of the key findings, data regarding costs to consumers, energy statistics, a discussion of revenue generated from carbon legislation, and recommendations.

KEY FINDINGS

1. North Dakota is one of the most coal dependent states and its consumers will be impacted more than those in nearly any other state.
2. North Dakotans currently pay some of the lowest electricity rates in the nation.
3. Energy bills are regressive in nature and higher energy costs will harm low-income customers the most.
4. Increased energy prices will result in an overall increase in costs of goods and services.
5. Abrupt changes in energy policy could be inefficient and cause undue harm, both from an economic and electric reliability standpoint.
6. Commercial scale carbon capture technology is still in its infancy.

COSTS TO CONSUMERS

Several utility company representatives cited specific examples of what costs their customers will likely face if carbon cap legislation is approved by Congress. Many of the utility executives believe it is possible for cap and trade legislation to result in an initial "tax" of $20 per ton on carbon emissions, with the cost being increased over time.

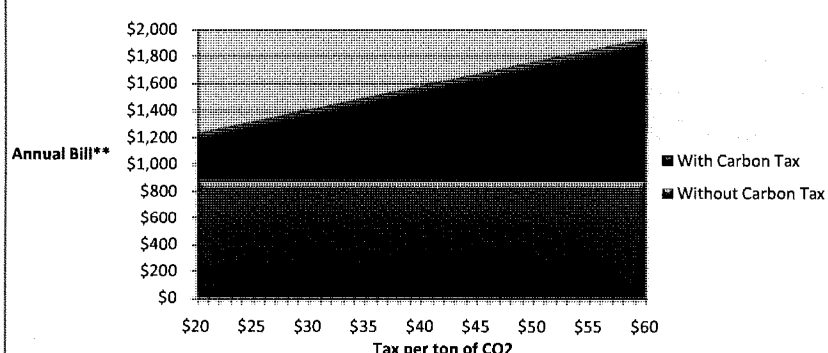
The following is a recap of some of the statements made regarding costs:

- **Dave Goodin**, CEO of Montana-Dakota Utilities Co., said if a $20 per ton tax is placed on carbon emissions, it would result in a 40 percent increase in MDU's residential customers' bills assuming there are no emission allowances issued. Mr. Goodin also stated that industrial customers could see a 52 percent increase in their bills. See attachment for an example of what an MDU bill would look like if a $20 per ton tax is placed on carbon emissions.
- **Dave Loer**, CEO of Minnkota Power Cooperative, said rates for Minnkota customers would increase 25 percent for every $10 per ton tax placed on carbon emissions. Mr. Loer said an alternative to cap and trade would be to place a modest tax of $1 a ton on carbon emissions and use the funds for research and development.

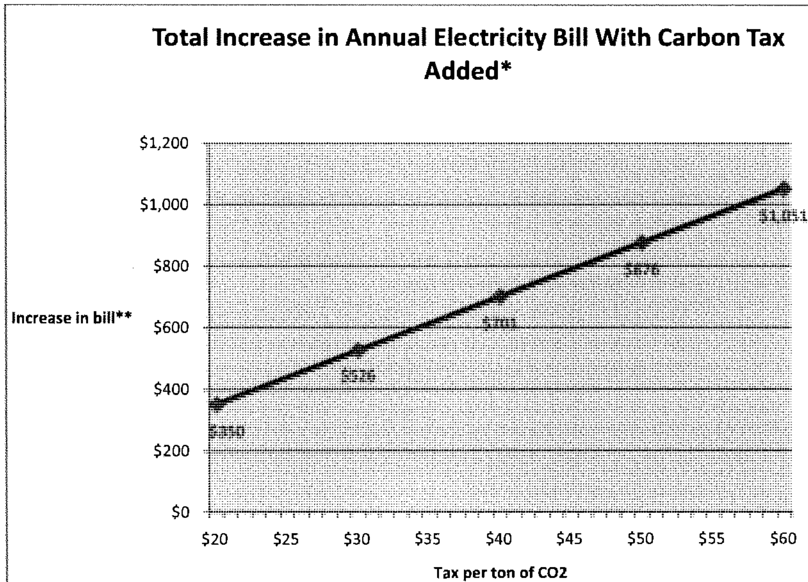
- **Ron Harper**, CEO of Basin Electric Power Cooperative, said cap and trade could cost consumers of Basin Electric's customers $498 million in 2012, with North Dakota customers paying $99 million of that.
- **Harlan Fuglesten,** Community and Governmental Relations Director for the North Dakota Association of Rural Electric Cooperatives, said based on a recent report of the National Rural Electric Cooperative Association, North Dakota customers would see the largest increases in rates among cooperatives if a carbon cap and trade plan is passed. Fuglesten said the average North Dakota cooperative customer would see their bills increase $25 a month if the tax is set at $20 per ton on carbon emissions.
- **Chuck MacFarlane,** president of Otter Tail Power Company, said every $10/ton tax on carbon emission would increase residential and small commercial rates by 12.5 percent and it would increase industrial rates by 16 percent.

The following charts demonstrate the increase in electricity rates based on the assumption that a $20/metric ton tax on carbon emission would result in a 40 percent increase.

Impact of Carbon Tax on Annual Electricity Bill*



*Assumes a 40 percent increase in rates per $20/metric ton tax.
**Based on the average price of retail electricty in North Dakota of $0.073 per kilowatt hour, according to data from the Energy Information Administration published January 2009 (http://www.eia.doe.gov/cneaf/electricity/epa/fig7p5.pdf). Graph assumes monthly usage of 1,000 kilowatt hours



*Assumes a 40 percent increase in rates per $20/metric ton tax.
**Based on the average price of retail electricty in North Dakota of $0.073 per kilowatt hour, according to data from the Energy Information Administration published January 2009 (http://www.eia.doe.gov/cneaf/electricity/epa/fig7p5.pdf). Graph assumes monthly usage of 1,000 kilowatt hours

KEY STATISTICS

In order to understand how much of an impact cap and trade will have on electricity rates in North Dakota, it is important to know what percentage of electricity is generated with coal, the primary target of the policy.

Coal is currently the most dominant fuel used for electricity generation in the United States and North Dakota. In 2008, coal was the source for about half of the electricity produced nationwide.

The following charts illustrate just how important coal is to generating electricity in the U.S. and North Dakota specifically.

2008 Generation Percentage by Fuel Source (U.S.)	
Coal	48.5%
Natural Gas	21.3%
Nuclear	19.7%
Hydro	6.1%
Non-hydro renewable	3%
Fuel Oil	1.1%
Other	0.3%

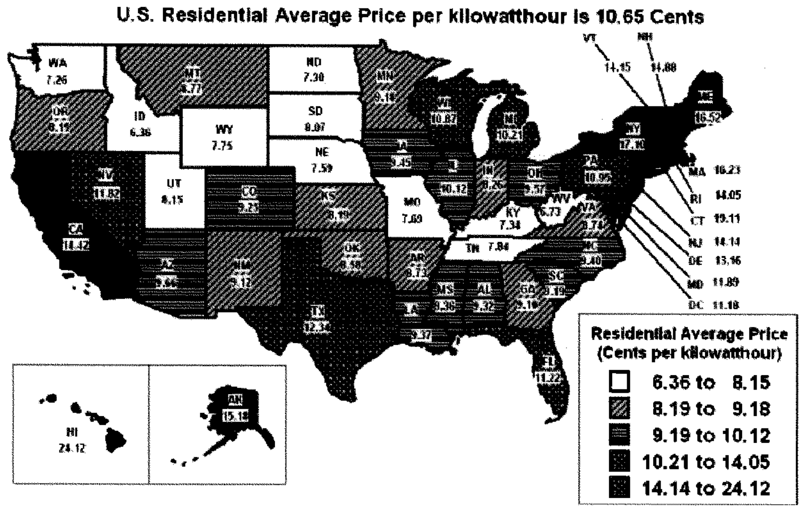
Source: U.S. Department of Energy, Energy Information Administration
(http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html)

Cap and trade will have a disproportionate impact on North Dakota ratepayers because of the state's heavy reliance on coal as a source of fuel.

State	% electricity from coal
1. West Virginia	98
2. North Dakota	**95**
3. Wyoming	95
4. Indiana	94
5. Utah	94
6. Kentucky	91
7. Ohio	87
8. Missouri	85
9. New Mexico	85
10. Iowa	78

The Commission is concerned about President Obama's Cap and Trade plan because it would require citizens of states that are coal dependent to pay the most, without a targeted return of that money. It is also important to note that federal law mandated the least cost generation be built in North Dakota and much of the heartland, which was effectively a coal mandate. The following illustration from the Energy Information Administration shows the cost effectiveness of the former federal energy policy.

Average Residential Electricity Prices per kilowatt-hour 2007



Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."
http://www.eia.doe.gov/cneaf/electricity/epa/fig7p5.pdf

As shown above, North Dakota has the fourth lowest cost retail electricity prices in the nation.

If North Dakota's ratepayers are disproportionately harmed by Cap and Trade, so too will ratepayers in other states who import electricity generated in North Dakota. North Dakota exports approximately two-thirds of the electricity produced in the state.

POTENTIAL GOVERNMENT REVENUE

Because of the significant amount of money that could be generated for government coffers under a cap and trade policy, there is much concern from policymakers and utilities over how that money will be spent. There is also concern about the potential for market manipulation and arbitrage under a complex regulatory scheme like cap and trade. Dr. Andrew Keeler, an economist on the faculty of the John Glenn School of Public Affairs at Ohio State University, said the question of how the money will be spent is the "many billion dollar question."

The consensus among utility representatives in attendance was: If carbon regulation is implemented, the revenue should be used to reduce carbon emissions, not for other types of spending such as for social programs or other government functions.

Keeler said some of the ideas of where the revenue would go include giving money back to ratepayers, using it to reduce taxes or the budget deficit, or for research and development. Keeler added that the political reality is there will likely be an auction mechanism and the federal government will receive the revenue.

In comments filed with the Commission, Xcel Energy cautions policymakers on auctioning 100 percent of the greenhouse gas allowances:

> *"Although President Obama has endorsed the auction of 100% of greenhouse gas allowances under a cap-and-trade program, we believe that emission allowances should be allocated freely to the utility industry. A large free allocation of allowances appears to be the best way to mitigate the cost of the program to utility customers. Any cap-and-trade program that requires 100% auction of allowances effectively requires utility customers to pay twice for the program: first to reduce emissions to meet the emission reduction goals, and second to purchase allowances to cover the utility's remaining emissions at auction. Without a large allocation, even a company that reduces its emissions by a significant amount would still face a significant obligation to purchase allowances. We strongly encourage the Commission to help advocate to Congress on this issue, as we believe it has significant consequences for our customers."*

RECOMMENDATIONS

Many see cap and trade as a perpetual tax on everyone that will not only affect energy rates, but also prices for goods and services that people buy. Based on the concerns and data presented at the summit, **the Commission opposes cap and trade.** However, the Commission would offer the following recommendations if Congress does proceed with a cap and trade law:

- Revenue generated from any carbon regulation should be targeted for carbon technology research and development, not as an excuse for further government spending. In no instance should cap and trade become a new general government revenue source. Doing so would ensure that North Dakotans would pay a disproportionate share of the cost of federal government spending.
- Any effective solution must be global. All carbon emitting countries like China need to be involved.
- All sources of energy must be included in Cap and Trade. Carbon regulation cannot be targeted only at electricity ratepayers.

- Targets should be achievable and timed with technology advancements, not based on unrealistic or arbitrary Congressional mandates.
- Reduction proposals should have safeguards so the economy and consumers don't suffer.
- There needs to be protections against market manipulations and large price swings. Emission reduction proposals, such as cap and trade, must include an economic safety valve to avoid excessive financial hardships, market manipulation or large price swings.
- Local distribution utilities should receive free allowances for emissions. State regulation ensures that this will not become a "windfall" for utility shareholders. Free allowances help mitigate the potential for skyrocketing electricity rates that are inherent in the President's 100 percent auction model.

The Commission does hasten to note, that even if the recommendations listed above are included in the legislation, it finds the cap and trade concept so inherently flawed and harmful to North Dakota consumers, that it is still a proposal that should be rejected by Congress.

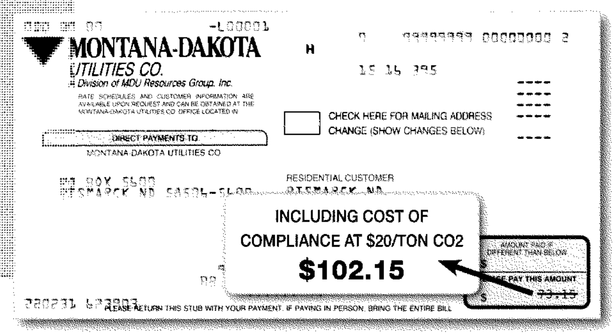
CONCLUSION

Few, if any, doubt cap and trade policies will result in increased costs for electricity nationwide. It is essentially a tax that will not only drive up energy prices, but it will also increase the prices for nearly everything bought and sold in the U.S. Utility company representatives are very concerned about how cap and trade will increase prices for their customers and they are already working on ways to mitigate the impact. In general, most utility companies share the same concerns over cap and trade legislation. Because the Commission regulates the rates of investor-owned utilities in North Dakota, it has an interest in protecting consumers by keeping rates reasonable, while at the same time allowing companies the resources to provide safe and reliable energy to their customers.

--END--

Cap-and-Trade Legislation Must Protect Customers and Economy

Cost Impact for North Dakota MDU customers at $20/ton assuming no emission allowances issued



Assumed Cost per Ton $20	Monthly Kwh Use	Current Avg Monthly Bill	Monthly Carbon Tax on Kwh Use	Full-year Carbon Tax	Bill % Increase
Residential - Single Family Home	1,100	$73	$29	$348	39.7%
Residential - Electric Space Heating	2,746	$166	$73	$876	44.0%
Small Retail Store	9,381	$731	$250	$3,000	34.2%
Restaurant	32,420	$2,258	$864	$10,368	38.3%
Clinic	45,735	$3,159	$1,219	$14,628	38.6%
Government Facility	140,345	$9,288	$3,742	$44,904	40.3%
Industrial	607,000	$30,919	$16,183	$194,196	52.3%

Montana-Dakota Utilities believes that federal action to reduce greenhouse gas emissions must:

- Involve all sectors of the economy, and all significant sources of GHG emissions;
- Prevent harm to the U.S. economy and minimize disproportionate regional impacts;
- Recognize that both alternative and traditional fuels such as coal, nuclear, natural gas and hydropower are critical to provide America with economic and reliable energy;
- Devote any revenue generated to developing affordable and reliable lower-carbon and carbon capture technologies;
- Assure compliance timelines are consistent with the development and deployment of needed technologies;
- Ensure that emissions less than an established cap are not assessed a price or cost;
- Provide an effective economic safety valve (e.g. carbon allowance ceiling price);
- Recognize early actions/investments made to mitigate greenhouse gas emissions;
- Allow federal GHG reduction requirements to preempt state or regional GHG reduction requirements; and
- Protect U.S. jobs from international competitors that do not face the same carbon constraints, while facilitating technology transfer to other nations.

Senator BOXER. Thank you very much.

I would like to put into the record two documents, too, at this point. One is the map that shows the modest impact on electricity rates, including in your parts of the country, and then also page 1 of the EPA analysis that says the cap and trade policies outlined in these bills would transform the way the U.S. produces energy. The average loss in consumption per household will be relatively low, and this is the key thing, the impacts of climate policy are likely to vary comparatively across geographic regions.

You keep saying California. I also would put a third document into the record that says green States to get few rewards in U.S. climate bill. And we are a green State with extensive energy efficiency.

[The referenced EPA document follows:]

Economic Impacts of S. 1733: The Clean Energy Jobs and American Power Act of 2009

October 23, 2009

U.S. Environmental Protection Agency
Office of Atmospheric Programs

On September 30, 2009, Senators Kerry and Boxer introduced the Clean Energy Jobs and American Power Act of 2009 (S. 1733). The counterpart bill in the House of Representatives is the American Clean Energy and Security Act of 2009 (H.R. 2454), for which EPA developed cost estimates on June 23, 2009. This paper presents a discussion of how some of the key provisions in the Senate bill compare to the House bill, particularly with respect to the likely economic impacts of the bill. In order to produce this analysis, EPA synthesized the results of a significant volume of modeling analysis on economy-wide climate policy performed by the Agency. This effort drew from the nearly 50 modeling scenarios of five bills over the past two years, with particular focus on the two economic analyses of the Waxman-Markey bill this year. Through this effort, we carefully assessed the key differences and whether any would result in substantial changes to the modeled impacts.[1]

The assessment in this paper draws upon existing modeling by EPA that used full computable general equilibrium models (ADAGE and IGEM), as well as modeling that used reduced form versions of EPA's models. These models serve as stylized versions of the U.S. economy and climate change policy. In effectively simplifying the real-world in order for a modeling analysis to be computationally feasible, it is important to recognize that some minor differences between the policy designs in H.R. 2454 and S. 1733 are made irrelevant by the set-up of the models. This is not unique to the set of models employed by EPA, but common among the broader modeling community. Nonetheless, reviewing the breadth of the EPA modeling scenarios provides an opportunity to identify the most important, robust conclusions that models can illuminate about the design of climate policy.

EPA's assessment of the two bills indicates that the full suite of EPA models would likely show that the impacts of S. 1733 would be similar to those estimated for H.R. 2454. Four key messages from the EPA analysis of H.R. 2454 would remain unchanged: (1) the cap-and-trade policies outlined in these bills would transform the way the United States produces and uses energy; (2) the average loss in consumption per household will be relatively low, on the order of hundreds of dollars per year in the main policy case; (3) the impacts of climate policy are likely to vary comparatively little across geographic regions; and (4) what we assume about the actions of other countries has much greater implications for the overall impact of the policy than the modeled differences between the two bills.

That said, there are a few differences between S. 1733 and H.R. 2454 that could have a small impact on the modeled costs of the policy. First, the 2020 cap level in S. 1733 requires a 20% reduction from 2005 emissions levels instead of the 17% reduction required in H.R. 2454, although this is the same 2020 target as modeled in the April 2009 analysis of the Waxman-Markey discussion draft. Moving from a 17% to 20% target would raise costs slightly in the models. Second, S. 1733 allows landfill and coal mine CH_4 as offset sources, whereas H.R. 2454 instead subjected them to performance standards. This will lower costs slightly and result in a small increase in overall

[1] Note also that EPA's analysis did not examine the costs of not acting to reduce greenhouse gases nor does it compare the costs of S. 1733 against other policy approaches to address GHG emissions.

emissions. Third, the market stability reserve allowance provisions in S. 1733 are changed to provide greater price certainty than the strategic reserve allowance provisions in H.R. 2454. S. 1733 also allocates more allowances to the market stability reserve than H.R. 2454 allocates to the strategic reserve. Assuming allowance prices remain low enough that covered entities do not purchase reserve allowances, this change will result in slightly higher costs in S. 1733 compared to H.R. 2454. For the most part the differences between the bills result in relatively small differences in estimated costs and may even cancel each other out on net.

There are many similarities between the bills. While the 2020 caps differ, the caps start out the same in 2012, and are identical between 2030 and 2050. Cumulatively, the caps differ by just one percent over four decades. Both of the bills cover the same sources of greenhouse gas emissions. Both bills place limits on offsets that are not expected to be binding. Both bills allow offsets from a broad array of agriculture and forestry sources. Both bills allow unlimited banking of allowances. Both bills have output-based rebate provisions designed to reduce emissions leakage and address competitiveness concerns for energy intensive and trade exposed industries. Because of these many similarities and the relatively small differences between the two bills, it is likely that a full analysis of S. 1733 would show economic impacts very similar to H.R. 2454.

EPA analysis mainly focuses on modeling the cap-and-trade policy outlined in proposed legislation. With time, EPA has also been able to incorporate a few additional provisions into its models, such as energy efficiency standards. EPA has not yet been able to adequately incorporate other standards within the modeling framework such as those that apply to the transportation or electricity sectors (e.g., fuel economy or performance standards). Likewise, while formal modeling can shed light on the key aspects of the cap-and-trade policy, it cannot replicate every aspect of private decision-making and therefore will not capture the impact of certain details. For this reason, modeling results are instructive in highlighting the magnitude and direction of impacts and the way they may change under different conditions but should not be interpreted as precise estimates of what will occur once a policy has been implemented.

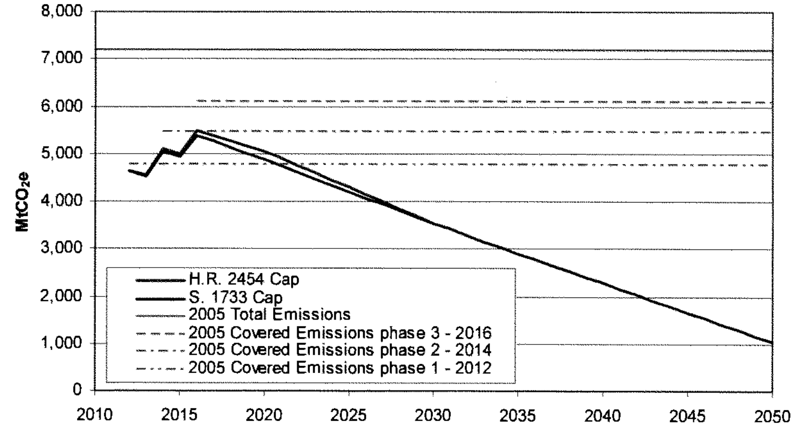
The paper is organized as follows. First, it evaluates key elements of the two bills that, in most cases, are informed by EPA modeling analyses: cap levels and coverage, offset limits and sources, banking and borrowing, reserve allowances, energy efficiency provisions, incentives for CCS, energy-intensive and trade-exposed output-based rebates, transportation provisions, and allocations. For each of these topics, the paper describes the purpose of the provision and how the bills differ, then assesses how these differences would be expected to impact allowance prices and costs. Second, the paper summarizes the economic impacts of H.R. 2454 and S. 1733. Third, it discusses the importance of modeling assumptions, particularly with regard to technology and international action. Fourth, distributional and temperature impacts are discussed. Finally, the appendix describes the recent EPA modeling analyses that inform this paper.

Cap Levels and Coverage

Both H.R. 2454 and S. 1733 place caps on the overall amount of greenhouse gas emissions allowed from all covered entities by establishing a separate quantity of emissions allowances for each year. In addition to establishing a cap, H.R. 2454 and S. 1733 allow covered sources to trade allowances. The requirement that a covered entity hold an allowance for every ton of greenhouse gas emissions it emits creates scarcity in the market for allowances, which in turn implies a positive price in the market. The cap-and-trade policy does not mandate how sources achieve this goal. Absent other legislated requirements, a source can choose the cheapest method of compliance, by reducing its output, changing its input mix, modifying the underlying technology used in production, or purchasing allowances or offsets from other entities with lower abatement costs. This assures that the cap is met at the cheapest possible cost to covered sources while inducing long-term innovation and change in the production and consumption of energy-intensive goods in related markets. The cap-and-trade policy often is carefully crafted to afford sources numerous flexibilities that further decrease the costs of compliance, such as the option to purchase offsets from non-covered sources; the ability to bank or borrow allowances across time periods; and the ability to purchase allowances from the government if the price reaches a particular threshold. Standards that impose restrictions on the way in which a particular subset of sources meet the cap will reduce this flexibility and, if binding, likely increase the costs without delivering additional emission reductions. However, it is difficult to model the effects of such standards on the behavior of sources and to reflect the costs they may impose.

Both H.R. 2454 and S. 1733 set the cap level in 2012, 2030, and 2050 to reduce emissions from covered sources by 3%, 42%, and 83% from 2005 levels respectively. However, compared to HR. 2454, S. 1733 changes the 2020 cap level from 17% to 20% below 2005 emissions levels from covered sources. It should be noted that the caps specified in S. 1733 are equivalent to the caps first specified in the Waxman-Markey discussion draft, which was also analyzed by EPA (EPA 2009a). This change in the 2020 cap level decreases the cumulative number of allowances available between 2012 and 2050 by one percent from 132.2 gigatons carbon dioxide equivalent ($GtCO_2e$) to 130.6 $GtCO_2e$. Figure 1 illustrates the nearly imperceptible difference, which is indicated by the gap between the lines representing the two cap levels over time. Because covered entities are allowed to bank, and to a limited extent, borrow emissions allowances, it is the cumulative number of allowances over the entire 2012 – 2050 time frame that drives allowances prices. All else being equal, this tightening of the cap will raise allowance prices on the order of one percent in all years from the allowance price in the core scenario of EPA's H.R. 2454 analysis ($13/$tCO_2e$ 2015; $16/$tCO_2e$ in 2020). Similar changes would be seen in the cost of the bill for the average household. The changed caps will also likely result in slightly greater usage of domestic and international offsets, all else being equal.

Figure 1 – S. 1733 and H.R. 2454 Cap Levels



The coverage in S. 1733 is unchanged from H.R. 2454. Both bills contain three separate phases each covering a greater percentage of emissions. In phase 1, from 2012 – 2013, covers 66.2% of year 2005 greenhouse gas emissions as measured in the Inventory of US Greenhouse Gas Emissions and Sinks (EPA 2008c). In phase 2, from 2014 – 2015, 75.7% of year 2005 greenhouse gas emissions are covered. In phase 3, 2016 and after, 86.4% of year 2005 greenhouse gas emissions are covered.[2]

Offset Limits and Sources

H.R. 2454 and S. 1733 both establish offsets credits as an additional method for entities to comply with the requirement to hold an emissions allowance for each ton of greenhouse gas emissions. Instead of purchasing an emissions allowance for each ton of emissions, entities may also demonstrate compliance by purchasing an offset credit that represents reductions in greenhouse gas emissions (or increased sequestration of greenhouse gases) from a non-covered source (e.g., reduced emissions from landfill CH_4, increased CO_2 sequestration from changed agricultural tillage practices, or increased CO_2

[2] Major sources covered in phase 1 include: CO_2 from electric power generators; CO_2 from non-industrial petroleum use; some CO_2 from industrial usage of petroleum; CO_2 from the non-energy use of fuels; N_2O from product uses; PFC from semiconductor manufacturing; and SF_6 from electrical transmission and distribution, magnesium production and processing, and semiconductor manufacturing. Major sources covered in phase 2 include: CO_2 from industrial usage of coal; remaining CO_2 from industrial usage of petroleum; most CO_2 from the industrial usage of natural gas; CO_2 from iron and steel production; CO_2 from cement manufacturing; CO_2 and N_2O from fertilizer production. Sources covered in phase 3 include: CO_2 from residential, transportation, and commercial usage of natural gas; remaining CO_2 from industrial usage of natural gas. See the data annex to EPA's analysis of H.R. 2454 (EPA 2009b) for a spreadsheet detailing covered sources.

sequestration from afforestation). The non-covered sources providing offset credits can either be domestic or international.

Table 1: Summary of Key Offset Provisions

	H.R. 2454	**S. 1733**
Overall Offset Limits	2 billion tons	2 billion tons
Source Level Offset Limits	Does not aggregate to the overall limit	Aggregates to the overall limit
Domestic & International Offset Limits	International: 1 billion tons Domestic: 1 billion tons	International: 0.5 billion tons Domestic: 1.5 billion tons
Criteria for Adjusting International Offset Limit	Domestic offset usage below 0.9 billion tons	Domestic offset usage below 0.9 billion tons
Revised International Offset Limit	1.5 billion tons	1.25 billion tons
Performance standards	Landfill and coal mine CH_4 covered by performance Standards, reducing there ability to supply offsets.	Landfill and coal mine CH_4 are not covered by performance standards.

Offsets Limits

Both H.R. 2454 and S. 1733 limit annual offset usage to 2 billion tons,[3] and then specify how the overall offset limit should be calculated on a per covered source basis to generate source level limits on the use of offsets.[4] The formula for establishing the source level offset limit in H.R. 2454 does not add up to the overall 2 billion ton limit.[5] S. 1733 corrects this problem so the source level limit is now consistent with the overall 2 billion

[3] H.R. 2454 sec. 722 (d)(1)(A) and S. 1733 sec. 722 (d)(1)(A).
[4] H.R. 2454 sec. 722 (d)(1)(B) and S. 1733 sec. 722 (d)(1)(B).
[5] H.R. 2454 Sec 722 (d) (1) (A) allows covered entities to satisfy a specified percentage of the number of allowances required to be held for compliance with offsets credits. H.R. 2454 Sec 722 (d) (1) (B) states that for each year, the specified percentage is calculated by dividing two billion by the sum of two billion and the annual tonnage limit for that year. For example, in 2012, when the cap level is 4.627 GtCO2e, the percentage would be 30.20%; and in 2050, when the cap level is 1.035 GtCO2e the percentage would be 65.90%. The number of allowances required to be held for compliance is equal to the amount of covered emissions, so for any given firm the amount of offsets they are allowed to use is equal to the product of their covered emissions and the percentage specified above. The total amount of offsets allowed is equal to the product of the total amount of covered emissions and the specified percentage. In order for this to be equal to the 2 billion ton limit on offsets specified above, total covered GHG emissions would have to be equal to the cap level plus 2 billion tons. There are several reasons why this is unlikely to be the case. First, even if covered emissions remain at reference levels, in the early years of the policy they will not be 2 billion tons over the cap level. Second, if firms bank allowances, their covered GHG emissions will be reduced, which will reduce the amount of offsets they are allowed to use. Third, in the later years when firms are drawing down their bank of allowances, it is possible for covered GHG emissions to be more than 2 billion tons above the cap, which means that the pro rata sharing formula can be in conflict with the overall 2 GtCO2e limit on offsets usage.

ton limit on offset usage.[6] For the purposes of economic analysis or modeling, this change is not likely to have any impact on allowance prices, as the limits on offset usage were not binding in EPA's analysis of H.R. 2454, and the revised limits in S. 1733 would also not be constraining.

In addition to the overall limits placed on the amount of offsets a covered entity can use, both H.R. 2454 and S. 1733 place limits on the amount of offsets that can come from either international or domestic sources. H.R. 2454 states that not more than one-half of offsets can come from domestic offset credits and not more than one-half can come from international offset credits. S. 1733 differs from H.R. 2454 in that not more than three-quarters of offsets can come from domestic offset credits and not more than one-quarter can come from international offset credits.[7]

After placing limits on domestic and international offset usage, both H.R. 2454 and S. 1733 state conditions under which those limits are modified. In both bills, if the estimated usage of domestic offsets is expected to be below 0.9 billion tons in any year, the limits on international offsets usage are modified. When this condition is met, H.R. 2454 allows additional international offset credits equal to the difference between 1 billion tons and the amount 1 billion tons exceeds the estimated domestic offset usage, up to an additional 0.5 billion tons of international offset credits. This has the potential to increase the limit on international offset credits in H.R. 2454 to 1.5 billion tons per year. In contrast, when this condition is met, S. 1733 allows additional international offset credits equal to the difference between 1.5 billion tons and the amount 1.5 billion tons exceeds the estimated domestic offset usage, up to an additional 0.75 billion tons of international offset credits. This can potentially increase the limit on international offset credits in S. 1733 to 1.25 billion tons per year, 0.25 billion tons less than in H.R. 2454.[8]

In EPA's analysis of H.R. 2454, estimated usage of domestic and international offsets are below the limits established in H.R. 2454, and below the limits established in S. 1733 in all scenarios that do not place constraints on technology. Thus the changed language on offsets limits will not impact the costs of the bill as estimated by EPA in scenarios that do not place limits on technology. However, in scenarios with limits on the availability of technologies such as nuclear, biomass, and CCS, the limits on international offset usage would be reached. In these scenarios, when the limit on domestic offsets is not met, H.R. 2454 adjusts the limit on international offset usage to allow approximately 1.5 $GtCO_2e$ per year, while S. 1733 adjusts the limit on international offset usage to allow 1.25 $GtCO_2e$ per year. The fewer international offsets allowed by S. 1733 compared to H.R. 2454 in these limited technology scenarios would require an extra 9.5 $GtCO_2e$ of abatement from covered sources cumulatively over the 2012 – 2050 time frame, and would result in higher allowance prices.

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[6] S. 1733 sec. 722 (d)(1)(B) establishes the entity level limit on offsets as the product of 2 billion tons and that entity's share of covered emissions from the previous year.
[7] H.R. 2454 sec. 722 (d)(1)(B) and S. 1733 sec. 722 (d)(1)(B).
[8] H.R. 2454 sec. 722 (d)(1)(C) and S. 1733 sec. 722 (d)(1)(C).

Coal Mine and Landfill CH_4: Offsets or Performance Standards

An additional difference between the two bills is that H.R. 2454 requires the establishment of performance standards for uncapped stationary sources including: any individual sources with uncapped emissions greater than 10,000 tons CO_2e; and any source category responsible for at least 20% of uncapped stationary GHG emissions. The bill requires that source categories to be identified by EPA include those responsible for at least 10% of uncapped methane emissions. Performance standards for new sources would then be set under the provisions of section 111 of the Clean Air Act. In general, performance standards are emissions limits set based on an analysis of best demonstrated technologies but do not require that particular technologies be used. Under section 111(d), states are then directed to set performance standards for existing sources based on the new source performance standards and may take into account other criteria such as a facility's remaining useful life. Sources that would potentially be covered by this provision likely includes, at a minimum: landfills; coal mines; and natural gas systems. Including these sources under performance standard provisions eliminates their eligibility to provide offset credits.

In S. 1733, these performance standard provisions are no longer included, and landfill, coal mine, and natural gas system methane are instead eligible to provide offset credits.[9] An extension of EPA's analysis of H.R. 2454 has shown that allowing these sources as offset projects under H.R. 2454 instead of covering them under performance standards would decrease allowance prices by 2% in all years from the allowance price in the core scenario of EPA's H.R. 2454 analysis ($13/t$CO_2e$ 2015; $16/t$CO_2e$ in 2020); increase 2012 – 2050 cumulative domestic offsets usage by 46% (6 GtCO_2e); decrease 2012 – 2050 cumulative international offset usage by 12% (5 GtCO_2e); and increase 2012 – 2050 cumulative U.S. GHG emissions by 6 GtCO_2e (Fawcett, 2009). The overall impact on the modeled cost of the policy would likely be small.

However, there are other general equilibrium consequences from the way that these emission sources are controlled that are not included in the reduced form modeling used to generate these results. Including these sources in an offsets program allows the market to determine the appropriate level of abatement from these sources so that the marginal cost of abatement is equal to the offset price. A performance standard dictates what level of abatement particular sources must achieve. If costs end up being lower than expected, then there will be less abatement activity than under an offsets program, although sources may be able to over-comply and generate additional offsets; if costs end up being higher than expected, there will be more abatement activity than under an offsets program, and the marginal cost of abatement for these sources will be higher than for sources covered by the cap.

[9] Note that S. 1733 gives the EPA Administrator discretion to set performance standards for uncapped sources after 2020, which could affect the availability of offsets from these sectors. Previous EPA modeling of climate legislation has generally assumed that such discretionary options are not exercised.

Domestic Agriculture and Forestry Offset Provisions

The domestic offset provisions in S.1733 are unchanged from H.R. 2454 in regard to their treatment of agriculture and forestry offsets. EPA's analysis uses the FASOM model because it is the only agricultural sector model that supports a comprehensive analysis of dynamic physical and economic responses to carbon policy. FASOM includes three important feedback effects: potential revenue from sale of offsets, producer response to changing input costs, and consumer demand responsiveness. FASOM features a broad range of offset-generating activities. Specifically, EPA estimates that 100 million metric tons of carbon could be sequestered by 2040 in agricultural soils alone. Overall, agricultural producer's surplus increases by 14% (in annuity terms) over the full period of analysis.

EPA's analysis of H.R. 2454 is intended to provide an estimate of domestic offset supply; it is not meant to prejudge what sources would be eligible for offsets. Several independent and follow-on studies have been recently undertaken to provide more detailed domestic agricultural and forestry results. In addition, the FASOM model has been updated over the summer (Baker *et al.*, forthcoming). Baker *et al.* (forthcoming) use the updated FASOM model, and their results show roughly twice as much carbon offset potential in agriculture compared to the March 2009 FASOM analysis on which EPA based its analysis of H.R. 2454, though the authors have not attempted to model specific eligibility or administrative issues. Baker *et al.* analyze results for crop and livestock producers across ten regions under three pricing levels, for a total of 120 combinations, and find all but 6 combinations yield net income increases. Summing the impacts to producers, processors, and consumers, the U.S. agriculture sector receives net annualized benefits of $1.2 billion - $18.8 billion. We expect that incorporating the updated FASOM results would result in greater domestic offset use yet remain below the revised limits on domestic offset use in both H.R. 2454 and S.1733.

International Offset Supply Estimates

EPA's analysis of H.R. 2454 used marginal abatement cost curves representing international abatement opportunities. The international non-CO_2 and terrestrial sinks abatement schedules were generated by first making assumptions about when developed and developing countries adopt climate policy; second, for each mitigation option a determination was made, dependent on whether or not the source country was assumed to have adopted binding caps, regarding potential eligibility for a future U.S. mitigation program, or in some cases applying a uniform adjustment;[10] third, separate offset mitigation cost schedules were constructed with eligible or adjusted options for developed and developing countries. International energy-related CO_2 abatement schedules were developed using the MiniCAM model. Specifically, the model was run using the reference case developed for the U.S. Climate Change Science Program Synthesis and Assessment Product 2.1a ("CCSP SAP 2.1a," US CCSP, 2006). International forestry related mitigation schedules were generated using the Global Timber Model.

[10] This determination of eligibility was not determined for methane from the natural gas and oil sectors, so uniform adjustments were applied.

In addition to generating the supply curve for international abatement, it is necessary to determine what the competing demand is for international abatement. This will determine how many international offsets are available for U.S. sources to purchase. Determining demand requires assumptions about the reference case emissions of developed and developing countries, and assumptions about the climate policies adopted by other countries. Greater reference case emissions growth, or tighter caps on emissions in other countries, increases international demand for abatement, and thus will drive up the price of international offsets, resulting in less U.S. reliance on them, all else being equal. This may result in greater use of domestic offsets. See the '*international actions*' section below that discusses how differing assumptions about international actions impact the results of the HR 2454 analysis. Also see the '*sensitivities on offset availability*' section below for a discussion of how differing assumptions about the availability of offsets, particularly international offsets, impact the estimated costs of climate policy.

Banking and Borrowing

Both H.R. 2454 and S. 1733 allow for unlimited banking of allowances, and some limited borrowing of allowances. Banking allowances allows covered entities to over-comply in the early years of the program so that covered greenhouse gas emissions, accounting for offsets, are below the cap. In the later, years the bank of allowances that has been built up can be drawn down so that covered greenhouse gas emissions, again accounting for offsets, are above the cap. While the cap is not met exactly in any given year, over time cumulative covered greenhouse gas emissions are equal to the cumulative cap.

Because of the option to bank allowances, the rate of return for holding allowances is expected to equalize with the rate of return from other available investments. For modeling purposes, this means that the allowance price will grow at an exogenously set interest rate. If instead the allowance price were rising faster than the interest rate, firms would have an incentive to increase abatement in order to hold onto their allowances, which would be earning a return better than the market interest rate. This would have the effect of increasing allowance prices in the present, and decreasing allowance prices in the future. Conversely, if the allowance price were rising slower than the interest rate, firms would have an incentive to draw down their bank of allowances, and use the money that would have been spent on abatement for alternative investments that earn the market rate of return. This behavior would decrease prices in the present and increase prices in the future. Because of these arbitrage opportunities, the allowance price is expected to rise at the interest rate.

In EPA's analyses a 5% interest rate is used for banking. For comparison, in the five models that participated in the Energy Modeling Forum 22 U.S. transition scenarios study,[11] the interest rate used for banking ranged from 4 to 5 percent (Fawcett, *et al.*,

[11] The Applied Dynamic Analysis of the Global Economy model (ADAGE) from the Research Triangle Institute; the Emissions Predictions and Policy Analysis model (EPPA) from the Massachusetts Institute of Technology; the Model for Emissions Reductions in the Global Environment (MERGE), from the Electric

forthcoming). In EIA's analyses of H.R. 2454 and other climate bills, the NEMS model uses a 7.4 percent interest rate for banking reflecting the average cost of capital in the electric power sector (EIA 2009). CBO's analyses of H.R. 2454 uses 5.6 percent as the interest rate for banking reflecting the after-tax long-run inflation-adjusted rate of return to capital in the U.S. nonfinancial corporate sector (CBO 2009). Thus, all else being equal, models that use a lower interest rate for banking show greater amount of banking, higher allowance prices in the early years as the bank is growing, and lower allowance prices in the later years as the bank is being drawn down.

Strategic Reserve / Market Stability Reserve

Both H.R. 2454 and S. 1733 set aside a portion of allowances to establish a reserve pool of allowances that are made available at auction if allowance prices rise high enough. Auction revenues from selling these reserve allowances can then be used to purchase offsets that are used to refill the reserve. These provisions are designed to contain price volatility, control costs, or both, depending on the specifics of the provisions. EPA has not assessed their ability to accomplish these stated goals. However, we do discuss the key differences between how these reserves are designed in H.R. 2454 and S. 1733 below.

The market stability reserve established in S. 1733 differs in important ways from the strategic reserve described in H.R. 2454. A key difference is that a greater number of allowances are taken out of the cap and placed in the reserve under S. 1733, as indicated in the table 2 below.

Table 2: Strategic / Market Stability Reserve Allocations

	HR. 2454	**S. 1733**
2012 – 2019	1%	2%
2020 – 2029	2%	3%
2030 – 2050	3%	3%

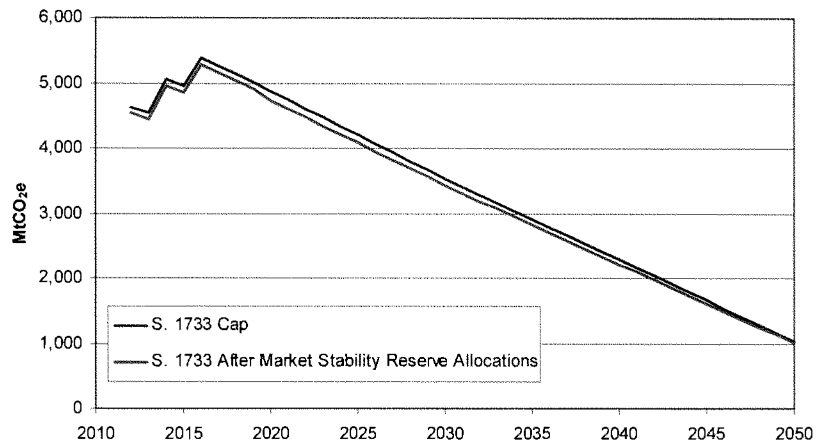
Cumulatively over 2012 – 2050, H.R. 2454 places 2.7 billion allowances in the strategic reserve, representing 2.1% of total allowances, while S. 1733 places 3.5 billion allowances in the market stability reserve representing 2.7% of total allowances. If allowance prices remain low and the minimum prices for releasing allowances from the reserves are not met, then the existence of the reserve has the effect of tightening the cap (see figure 2 below) and raising allowance prices.

While EPA did not model the strategic reserve mechanism in its analysis of H.R 2454, subsequent modeling has shown that including the reserve would increase allowance prices by approximately 1% in all years from the allowance price in the core scenario of

Power Research Institute; MiniCAM, from the Pacific Northwest National Laboratory / Joint Global Change Research Institute; the Multi-Region National Model - North American Electricity and Environment Model (MRN-NEEM), from Charles River Associates; and the Intertemporal General Equilibrium Model (IGEM), from Dale Jorgenson Associates

EPA's H.R. 2454 analysis (\$13/tCO_2e 2015; \$16/tCO_2e in 2020), and also increase the usage of international offsets. Because S. 1733 places a greater percentage of allowances in the reserve, it would result in a slightly larger increase in allowance prices in a scenario where allowance prices remain low enough that the reserve allowances are not purchased. For context, the change in the 2020 cap from 17% (H.R. 2454) to 20% (S. 1733 and Waxman Markey discussion draft) below 2005 levels reduces the cumulative number of allowances by 1.6 billion tons, and increases allowance prices by approximately one percent. The change in the allocation to the reserve in S. 1733 compared to H.R. 2454 reserves an additional 0.8 billion tons, and thus should have a smaller impact on allowance prices.

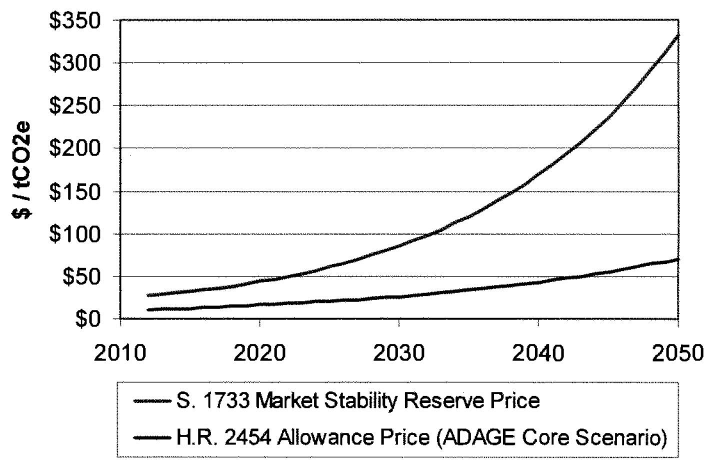
Figure 2 – S. 1733 Cap Levels with and without Market Stability Reserve



Another major change is how the minimum reserve price is set. H.R. 2454 sets the minimum reserve price at \$28 (in constant 2009 dollars) in 2012, and the price rises at a real rate of 5 percent through 2014. Starting in 2015, the minimum reserve price is set at 60 percent above the 36-month rolling average of that year's emissions allowance vintage. This way of setting the minimum reserve price allows the reserve to be triggered when price volatility leads to suddenly high prices; however, sustained non-volatile high allowance prices would not trigger the reserve. The strategic reserve in H.R. 2454 is primarily designed to address price volatility and not cost containment in general. This approach does not provide meaningful price certainty to inform business planning.

In contrast, S. 1733 sets the minimum reserve price at \$28 (in constant 2005 dollars) in 2012 rising at a real rate of 5 percent through 2017, then rising at a real rate of 7 percent thereafter. This change results in a predetermined minimum reserve price for every year, which can be met either by high allowance prices caused by price volatility, or by sustained non-volatile allowance prices. The market stability reserve in S. 1733 is designed to address both price volatility and cost containment in general. This approach provides better price certainty, although the price ceiling is not binding, depending on the outcome of the reserve auctions. Figure 3 below shows the minimum reserve price for S. 1733 with the estimated allowance price from H.R. 2454 for comparison. Note that the figure does not depict the minimum reserve price for H.R. 2454, as that price will vary depending on the realized allowance price.

Figure 3 – S. 1733 Market Stability Reserve



S. 1733 places limits on the number of reserve allowances that may be auctioned in each year. The limits are equal to 15% of the cap from 2012 – 2016 and 25% of the cap thereafter. These limits allow for the initial allowances placed in the reserve to be used very quickly. For example, if the minimum reserve price was reached immediately in 2012, and allowances were sold from the reserve up to the limit, then all of the 3.5 billion allowances initially placed in the reserve would be used by 2016.

If allowance prices are above the minimum reserve price, then the ability of the reserve to contain prices depends on the ability of the government to refill the reserve. If only the allowances initially placed in the reserve are auctioned, then the reserve will simply make allowances that were allocated to the reserve in later years available instead in early years, without any impact on the cumulative number of allowances available. This will have no impact on modeled allowance prices. If the reserve can be refilled, then auctioning these refilled reserve allowances would increase the amount of greenhouse gas emissions a covered entity could emit compared to a scenario with no reserve in the first place, and thus have the potential to reduce allowance prices.

S. 1733 allows reserve auction revenues to be used to purchase domestic and international offset credits that would be retired to create additional allowances to be auctioned under the market stability reserve. If offset credits are available for a price lower than the minimum reserve price, then they can be purchased to refill the reserve and help contain allowance prices. This situation would primarily be expected to hold when the limits placed on domestic or international offset usage are binding so that the market clearing offset price is lower than the allowance price. However, EPA's modeling has shown that the scenarios with the highest allowance prices generally have limits on the availability of technology and the availability of offsets. If offsets are not available for purchase through the offset market, resulting in high allowance prices, it is likely that they would also not be available to refill the market stability reserve. This, in turn, implies a limited ability of the strategic reserve to protect against sustained higher allowance prices when offset availability is limited.

Energy Efficiency Provisions

In EPA's analysis of H.R. 2454, three areas of energy efficiency provisions were addressed: building codes, energy efficiency-related allowance allocations, and the energy savings component of the Combined Efficiency and Renewable Electricity Standard (CERES). For modeling purposes, we assumed that one quarter of the CERES requirement would be met through electricity savings.[12] EPA did not model several other sections of the energy efficiency provisions, including lighting and appliance standards, smart grid advancement, industrial energy efficiency programs, and improvements in energy savings performance contracting.[13] It is also worth noting that in EPA's analysis of H.R. 2454 the energy savings and associated costs of the energy efficiency provisions are estimated outside of ADAGE and imposed exogenously into our policy scenarios. Thus, certain interactions may not be fully accounted for in EPA's analysis. Specifically, some overlap may exist between the estimate of impacts driven by the energy efficiency provisions and the price response-driven energy efficiency investments reflected within ADAGE.

Like H.R. 2454, S. 1733 includes a building codes provision and energy efficiency-related allowance allocations. However it does not include any provision comparable to the CERES of H.R. 2454. Unlike H.R. 2454, the building codes provision in S. 1733 does not specify target levels of reductions in energy use, federal authority to implement, or federal ability to withhold allowance allocations for non-compliance. Instead, the provision directs EPA, or another designated agency, to establish targets through rulemaking and does not provide for federal implementation or withholding of allowance allocations. The energy efficiency-

[12] The CERES requires retail electric suppliers to meet a growing percentage of their load with electricity generated from renewable resources and electricity savings. It begins at 6% in 2012 and gradually rises to 20% in 2020. One quarter of the requirement may be met through electricity savings. Upon petition by a state's governor up to 40% of the requirement may be met through electricity savings.

[13] Building codes are in Sec. 201; energy efficiency-related allowance allocations are specified in Sec. 321; and the Combined Efficiency and Renewable Electricity Standard (CERES) is specified in Sec. 101 of H.R. 2454. Lighting and appliance standards are in Sec. 211-219; smart grid advancement is in Sec. 141-146; industrial energy efficiency programs are in Sec. 241-245; and improvements in energy savings performance contracting are specified in Sec. 251.

related allowance allocations in S. 1733 (specified to EPA by Senate Environment and Publ Works Committee Staff) are very similar to those in H.R. 2454 except for the impact of the increase in allowances taken off-the-top for the strategic reserve and deficit neutrality. This effect reduces the energy efficiency-related allowance allocations by approximately 11% through 2029, 22% from 2030-2039, and 25% thereafter. The percentage allocations (befoi accounting for the impact of the off-the-top allocations) to natural gas, and home heating oi and propane consumers, as well as the minimum proportions that are required to be used fo energy efficiency, are identical to those in H.R. 2454. Similarly, the allocations to state anc local investment in energy efficiency and renewable energy and associated restrictions on uses are similar to those in H.R. 2454 on a percentage basis before accounting for the off-th top allocations.

In total, because there is no provision comparable to the CERES in H.R. 2454, the building codes provision does not specify target energy use reduction levels or provide federal authorities to ensure compliance, and the energy efficiency-related allowance allocations ar lower, EPA expects the impacts (e.g., changes in energy demand and prices) of energy efficiency provisions in S. 1733 to be approximately half those estimated in our analysis of H.R. 2454 . Specifically, the effects of these three areas of energy efficiency provisions are included in EPA's core policy scenario of H.R. 2454 and the combined effects of these provisions are highlighted through the "without energy efficiency provisions" scenario that removes them from the core policy scenario. The resulting modeled economic impacts of tl energy efficiency provisions include modest reductions in allowance prices (~1.5%), fossil fuel prices (coal and natural gas ~1%), and electricity prices (<1%) from 2015-2050.[14]

Incentives for CCS

Both H.R. 2454 and S. 1733 contain considerable financial incentives for carbon capture and storage (CCS) on new and existing facilities, as shown in table 3 below. The proposals each contain about \$10 billion (\$1 billion per year over ten years) for demonstration and early deployment of the technology in addition to bonus allowances that are awarded to early projects based upon the amount of CO_2 that is captured and sequestered. The early deployment funding is raised from fees on electricity sales. The bonus allowance pool under H.R. 2454 can award up to 5.32 billion allowances over the life of the program and 4.19 billion allowances under S. 1733. Fewer bonus allowances are available under S. 1733 due to that bill's more stringent 2020 cap, its allocation of a larger share of overall allowances to the market stability reserve, and its use of a larger share of overall allowances for deficit reduction. However, that difference does not necessarily translate to an equivalent difference between the bills in the aggregate monetary support for CCS or the effect on overall CCS deployment, for reasons described below.

[14] Note that the only analysis of the impact of the CERES on driving increased renewable electricity generation was conducted as a side case to the electricity sector modeling and not modeled within the core ADAGE policy case.

The CCS bonus is a monetary incentive for each ton of CO_2 sequestered, given in the form of allowances from the (limited) bonus pool. Thus, the number of allowances granted per ton of CO_2 sequestered is a function of the allowance price and the bill's per-ton monetary incentive. Under both H.R. 2454 and S. 1733, a pre-determined fixed per-ton value is given for the earliest projects up to a certain capacity threshold (referred to as a "tranche"). Subsequent projects must participate in a reverse auction approach where participants' bids help to determine the appropriate per-ton value that maximizes CCS deployment until the bonus allowance pool runs out. The per-ton value structure of the bonus in S. 1733 differs from H.R. 2454 whereby fixed per-ton values remain in effect for a larger share of initial CCS capacity (until 20 GW of capacity is built under S. 1733 versus 6 GW in H.R. 2454).

Table 3: Incentives for CCS

	H.R. 2454	**S. 1733**
Early Deployment	\$1 billion annually for 10 years	\$1 billion annually for 10 years
Total Bonus Pool	5.32 Billion	4.19 Billion
1st Tranche[15]	\$90/ton for first 6 GW + \$10/ton built before 2017	\$96/ton for first 10 GW + \$10/ton built before 2017
2nd Tranche	Reverse Auction	\$85/ton for next 10 GW
3rd Tranche	N/A	Reverse Auction

Note: bonus amount is for 90% capture. Lesser capture rates receive smaller bonus values.

It is possible that with a larger tranche of initial projects eligible for a fixed per-ton value incentive, S. 1733 may accelerate the deployment of CCS.[16] However, if the fixed per-ton values are higher than the market would accept to make all of those initial projects economic, the pool of bonus allowances will be exhausted earlier and will result in less total CCS purely arising from the bonus incentive. There are other factors that may act to increase CCS deployment under S. 1733, such as higher allowance prices and higher demand for electricity. In addition, by accelerating the early deployment of CCS technology, there could be some learning-by-doing that assists with accelerating the commercial viability of CCS.

[15] S. 1733 made changes to the definition of capacity that determines the thresholds for each tranche to apply to the "treated generating capacity" (Sec. 786) instead of the total capacity of the eligible generating unit under H.R. 2454. This would have no effect on EPA modeling.

[16] This approach is most likely intended to address risk rather than cost minimization and/or optimization, and so it may not be reflected in EPA modeling.

Energy Intensive / Trade Exposed Output Based Rebate Provisions

Both H.R. 2454 and S. 1733 establish output based rebates of allowances for covered entities that are both energy intensive and trade exposed (EI/TE). S. 1733 establishes rebates for EI/TE sectors, equal to the product of firm output, an industry average emissions factor, and the allowance price The eligibility criteria, language describing the rebate calculation, and phase-out schedule are mostly unchanged from H.R. 2454. The changes that have been made include changing the base year for the calculation of industry average emissions factors, and adding additional details about the way averages are calculated. The ADAGE model aggregates energy intensive manufacturing sectors in such a way that it masks the distinctions that might be supported by this language. The changed language would not affect the modeled costs of the bill or the modeled impacts on EI/TE sectors.

The EI/TE sectors would be affected by other provisions of S. 1733 that impact allowance prices. An analysis of the impacts of the EI/TE provisions under S. 1733 would be somewhat different than the analysis under H.R. 2454 because of the different cap and other changes that would affect allowance market conditions (e.g., larger amounts of allowances allocated off-the-top to the strategic reserve and deficit neutrality, and the alternative assumptions about international actions discussed below). These changes would likely have a relatively small impact on allowance prices and the overall costs of the policy.

Allocations

The initially released version of S. 1733 did not include information on the percentage of allowances allocated to or auctioned for various purposes. However, Senate Environmental and Public Works Committee staff have provided details on the allocation and auction percentages to EPA, and these details are expected to be included in the version of S. 1733 that will be introduced in committee. Some of the changes to allocations that impact specific provisions (e.g., energy efficiency allocations and reserve allowance allocations) are discussed above along with the likely impact the change will have on costs. One important change to note is that S. 1733 devotes a much greater portion of allowance to deficit reduction. S. 1733 auctions 10 percent of allowances for the purpose of deficit reduction from 2012 – 2029, 22% from 2030 – 2039, and 25% from 2040 – 2050. For comparison H.R. 2454 auctioned 13% of current vintage allowance for deficit reduction in 2012 and 2013 and approximately 1% from 2014 – 2025; in addition, from 2014 to 2020 it auctioned a number of future vintage allowances equal to 10% to 14% of cap levels. H.R. 2454 did not auction allowances for deficit reduction after 2025. However, EPA has a limited ability to evaluate the impact of such changes on modeled costs across proposals unless the changes result in behavioral change. This is because the models used by EPA are calibrated to deficit neutrality. As such, S. 1733 will bring the modeled costs of the policy closer to the truer measure of overall costs. Estimates of allowance prices and household costs will not be significantly affected by this change.

Summary of Economic Impacts

This paper has presented an assessment of how individual differences between S. 1733 and H.R. 2454 are expected to influence the costs of the bill. These assessments have drawn upon existing modeling by EPA that used the full computable general equilibrium models (ADAGE and IGEM), as well as modeling that used reduced form versions of EPA's models, and have focused on the effect the differences have on allowance prices and costs. It is likely that the full suite of EPA models would show that the impacts of S. 1733 would be similar to those that were estimated for H.R. 2454. We therefore summarize the main results from our analysis of H.R. 2454 in table 4 below.

Table 4: Summary of Economic Impacts of H.R. 2454[17]

		2015	2020	2030	2050
Allowance Price ($/t$CO_2$e)	Core scenario	$13	$16	$26-$27	$69-$70
	Range across all scenarios	$13-$24	$16-$30	$26-$49	$69-$130
Undiscounted household consumption loss, relative to no policy case, core scenario	Percent	0.03%-0.08%	0.10-0.11%	0.31-0.30%	0.76-0.78%
	Dollars per day	$0.06-$0.19	$0.23-$0.29	$0.76-$1.00	$2.50-$3.52
Percentage increase in household consumption increase from 2010	No policy case	8-10%	15-19%	31-41%	71-96%
	Core scenario	8-10%	15-19%	31-40%	69-94%
Electricity price increase, relative to no policy case	Percent	unchanged	unchanged	13%	35%
Household energy expenditure increase, relative to no policy case	Percent increase (decrease)	(2%)	(7%)	2%	21%
Share of low- or zero-carbon primary energy	No policy case	14%	14%	15%	14%
	Core scenario	15%	18%	26%	38%

EPA's analysis of H.R. 2454 shows that the bill would transform the structure of energy production and consumption, moving the economy from one that is relatively energy inefficient and dependent on highly-polluting energy production to one that is highly

[17] Ranges shown for the core policy run reflect the values for the two CGE models (ADAGE and IGEM) used in the EPA analysis of H.R. 2454. This range only reflects the differences in the models, and does not reflect the other scenarios or additional uncertainties..

energy efficient and powered by advanced, cleaner, and more domestically-sourced energy. Increased energy efficiency and reduced demand for energy resulting from the policy mean that energy consumption levels that would be reached in 2015 without the policy are not reached until 2040 with the policy. The share of low- or zero-carbon primary energy (including nuclear, renewables, and CCS) would rise substantially under the policy to 18% of primary energy by 2020, 26% by 2030, and to 38% by 2050, whereas without the policy the share would remain steady at 14%. Increased energy efficiency and reduced energy demand would simultaneously reduce primary energy needs by 7% in 2020, 10% in 2030, and 12% in 2050. Petroleum primary energy use declines by 0.4 million barrels per day in 2020, 0.7 million barrels per day in 2030, and 1.6 million barrels per day in 2050. Electric power supply and use, and offsets represent the largest sources of emissions abatement under H.R. 2454.

Electric power supply and use are an important part of achieving emission reductions under cap-and-trade programs and are likely to represent the largest source of emissions abatement under S. 1733, based upon previous EPA modeling. The power sector is a large source of cost-effective emission reductions, driven by the long-term caps placed on emissions of greenhouse gases and the resulting price signal, which transforms the nature of electric supply from higher-emitting technologies to lower- and non-emitting technologies like renewables, nuclear, and coal with CCS technology. Where perceived by consumers, the price signal also encourages improvements in end-use energy efficiency. By 2050, most fossil electricity generation would be capturing and storing CO_2 emissions and the power sector would largely be de-carbonized.

The timing and magnitude of the reductions within this sector largely depend on the existing coal fleet, which provides almost 50% of our nation's electricity. The allowance price is the most critical element, and much of the existing fleet remains economic at CO_2 prices below \$20 per ton. Additional policies and incentives beyond the pure cap-and-trade program, such as CCS bonus provisions or aggressive renewable generation requirements, can reduce the economic impact of the program on the existing coal fleet by lowering the allowance price. However, unless these policies are targeted to overcome specific market failures (such as suboptimal private investment in research and development), such provisions are likely to increase the overall costs of achieving emission reductions.

In the core scenario of EPA's analysis of H.R. 2454 estimated allowance prices were \$13/tCO_2e in 2015 and \$16/tCO_2e in 2020. Across scenarios, the allowance price ranged from \$13 to \$24/tCO_2e in 2015 and from \$16 to \$30/tCO_2e in 2020.

EPA estimated that H.R. 2454 would have a relatively modest impact on U.S. consumers assuming the bulk of revenues from the program are returned to households. With or without H.R. 2454, household consumption will continue to grow. Average household consumption is reduced by less than one percent in all years relative to the no policy case. On per household basis, these costs are \$0.23 to \$0.29 per day in 2020 and \$0.76 to \$1.00 per day in 2030. The average annual household consumption loss, calculated as the annual net present value cost per household with a discount rate of 5% and averaged over the 2010-2050 time period, is estimated to be $80 to $111 dollars per year relative to the no policy case. This represents 0.1 to 0.2 percent of household consumption. These costs include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital. Cost estimates also reflect the value of some of the emissions allowances returned to households, which offsets much of the cap-and-trade program's effect on household consumption. The cost estimates do not account for the benefits of avoiding the effects of climate change. A policy that failed to return revenues from the program to consumers would lead to substantially larger losses in consumption.

In the core scenario of EPA's H.R. 2454 analysis, electricity prices are unchanged in 2020 due to the assumption that allocations to LDCs are used to prevent electricity price increases. In 2030, due to the phase out of the LDC allocation, the electricity price is estimated to increase by 13% relative to the reference scenario. Actual household energy expenditures increase by a lesser amount due to reduced demand for energy. In 2020, the average household's energy expenditures (excluding motor gasoline) are estimated to decrease by 7% relative to the reference scenario, and in 2030 household energy expenditures are estimated to increase by 2%. In ADAGE, energy expenditures represent approximately 2% of total consumption in 2020, falling to 1% by 2050 in all scenarios.

The economic literature shows small variations in the gross costs of climate policy across regions. Data from two recent economic studies, published by researchers at the National Bureau of Economic Research (NBER) and Resources for the Future (RFF), both indicate that differences in gross cost by region are modest. These studies did not specifically examine the allowance allocation provisions of H.R. 2454. Thus, the comparisons displayed ignore the cost-mitigating effects of those provisions. The NBER study finds only small regional differences. The increase in households' spending would range from 1.9% of annual income (East South Central region) to 1.5% (West North Central Region) (Hassett, et al., 2008). The RFF study also finds only small regional differences. The increase in households' spending would range from 1.6% of annual income (Ohio Valley) to 1.3% (California, New York, and the Northwest) (Burtraw, et al., 2009).

Importance of Modeling Assumptions

All analyses of climate change legislation must make assumptions, and these assumptions will inevitably impact the estimated costs of the legislation. Assumptions about economic growth in the reference case will influence the resulting emissions in the reference case, and determine the amount of abatement required to comply with the cap.[18] Assumptions about the cost and availability of technology influence estimates of the marginal cost of abatement from covered sources. Assumptions about the cost and availability of offsets influence the amount of abatement from non-covered sources that can be used to reduce the amount of abatement from covered sources. Assumptions

[18] Fawcett et al., forthcoming, discusses how reference case emissions growth influences the cost estimates from the five models that participated in the Stanford Energy Modeling Form 22 U.S. transition scenarios study.

about climate policies adopted by other countries influence the cost and availability of international offsets, as well as the cost of globally traded energy goods. All of these assumptions will influence the estimated cost of climate policy. Most analyses of climate legislation contain multiple scenarios designed to highlight the assumptions and policy design choices that influence the estimated cost of the policy. In this section we discuss some sensitivity scenarios that highlight these important assumptions and uncertainties.

Sensitivities on Offset Availability

There are many institutional design issues, including the measurement, monitoring, reporting and verification requirements, surrounding estimates of offset availability. These issues must be addressed to ensure that the offset reductions are truly incremental, and represent real reductions. The EPA analysis of H.R. 2454 assumes that the institutions are put in place to process the domestic and international offsets needed to realize reductions on the magnitude shown in the analysis. Additionally, the cost and availability of offsets, particularly international offsets, is one of the greatest uncertainties in forecasting the cost of climate legislation. The U.S. will not be the only buyer of international offset credits, and the price of those credits will depend greatly on the competing demand for those credits. The stringency of climate policies adopted by other countries, the types of restrictions they place on international offset credits, and their expected reference case emissions growth all will influence the competing demand for international offset credits and the resulting price. Additionally, there is uncertainty on the supply side for both domestic and international credits that will influence the cost and availability of offsets.

All analyses that have looked at the issue have shown that the availability of offsets is one of the most important factors influencing allowance prices. EPA's analyses of the Waxman-Markey discussion draft and of H.R. 2454 showed that eliminating international offsets increased allowance prices by 96 and 89 percent respectively (EPA 2009a,b). MIT's analysis of H.R. 2454 examined two cases: a full offsets case with the full two billon metric tons of offsets available in each year, and a medium offsets case where the amount of available offsets ramp up linearly from zero in 2012 to the full two billon tons in 2050. The MIT analysis showed that the allowance price in the medium offsets case was 193 percent higher than the allowance price in the full offset case (MIT 2009). EIA's analysis of H.R. 2454 showed that compared to their 'basic' case,[19] the 'high offsets' case reduced allowance prices by 35 percent, and the 'no international offsets' case increased allowance prices by 64% (EIA 2009).

Offsets can have such a large impact on allowance price because, if they are able to provide low cost abatement from uncovered sources, they have the potential to greatly reduce the amount of emissions reductions needed from covered sources. The caps in S. 1733 allow covered sources to emit 131 $GtCO_2e$ cumulatively from 2012 through 2050. If the two billion tons of offsets allowed annually under H.R. 2454 were all used,

[19] It should be noted that in EIA's analysis of H.R. 2454, their 'basic' case allowed fewer offsets than were used in the core case of EPA's analysis of H.R. 2454.

cumulative emissions from covered sources would be allowed to be 60 percent (78 $GtCO_2e$) higher.

Both H.R. 2454 and S. 1733 allow for unlimited banking of allowances, and most modeling of H.R. 2454 assumes that banking does indeed occur. Because of the possibility of banking, the cumulative number of offsets available over the entire time horizon drives how the availability of offsets influences allowance prices, not the particular time path of when that cumulative amount of offsets is available. EPA's analysis of H.R. 2454 showed that delaying international offsets availability by 10 years resulted in only a three percent increase in allowance prices, because the cumulative amount of international offsets used was only reduced by four percent as a result of the 10 year delay, and firms would respond by banking fewer allowances in the near term and using more offsets in the years after they became available. It is important to note that these results are premised on optimal banking behavior over a 40-year period. Any restrictions on banking, limitations to credit to enable banking, or myopia (not looking beyond next 20 years would be sufficient myopia), would alter these results.

Technology Sensitivities

Another major source of uncertainty about the costs of climate change legislation is the cost and availability of low or zero-carbon technologies. Many analyses include sensitivities on the penetration of key technologies. In EPA's analysis of H.R. 2454, limiting nuclear power to reference case levels increased allowance prices by 15 percent relative to the core scenario. In EIA's analysis of H.R. 2454 the 'high cost' case, which assumed that the costs of nuclear, fossil with CCS, and biomass generating technologies are 50 percent higher than in the 'basic' case, had an allowance price 12 percent higher than the 'basic' case. In both of these analyses, the allowance price increases resulting from the restricted or high cost technology scenarios was somewhat dampened by the ability to increase the usage of offsets. The uncertainties surrounding the penetration of key technologies involve technical uncertainties about the cost and performance of new technologies, political uncertainties about the regulatory infrastructure required to license and permit the technologies, as well as uncertainties about the public's willingness to accept the expansion of technologies such as nuclear power and coal with CCS.

High Cost Scenarios

The highest cost scenarios included in various modeling efforts generally involve both restrictions on offsets and limitations on technology. In EIA's analysis of H.R. 2454, the 'no international / limited' case combines the offsets limits and high technology costs from their 'no international offsets' and 'high cost' cases. In this scenario, allowance prices are 194 percent higher than in the 'basic' case. This increase is significantly greater than when just technology is restricted, as offset usage can no longer increase to make up for the higher cost of abatement within covered sectors. EPA's past analyses show a similar result, where eliminating international offsets and restricting nuclear and CCS technologies significantly increases allowance prices (e.g., over 180 percent). The high allowance prices would increase the price U.S. firms would be willing to pay for international offset credits and make it more likely that international offset credits would be available. These scenarios are intended to represent the upper range of costs and can be included in analyses as part as a range of sensitivities designed to highlight important uncertainties and drivers of costs.

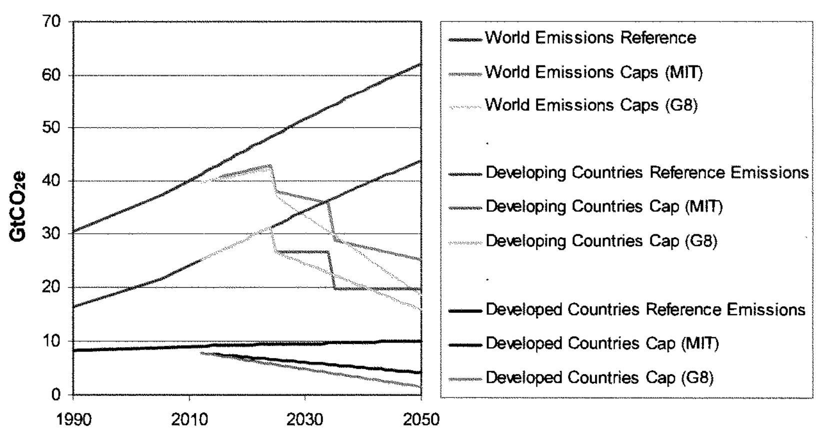
International Action

One development since EPA conducted its analysis of H.R. 2454 is that at the July 9, 2009 Major Economies Forum, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050, acknowledging the broad scientific view that warming should be limited to no more than two degrees Celsius." A set of international policy assumptions that is consistent with the G8 agreement is as follows:

- o Developed countries follow an allowance path that falls linearly from the Kyoto Protocol emissions levels in 2012 to 83% below 2005 in 2050.
- o Developing countries adopt a policy beginning in 2025 that caps emissions at 2015 levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
- o The combination of U.S., developed, and developing country actions caps 2050 emissions at 50% below 2005 levels.

This is a more stringent policy internationally than what was assumed in EPA's analysis of H.R. 2454, which were based on the international policy assumptions used in the 2007 MIT report, "Assessment of U.S. Cap-and-Trade Proposals." Figure 4 below depicts the cap levels in both sets of international policy assumptions for non-U.S. developed countries and developing countries, along with the total world emissions that result from the developed and developing country caps along with U.S. action.

Figure 4 –MIT and G8 International Climate Policy Assumptions



While this change in assumptions about climate change policies adopted by other countries is not a change to the bill, assuming that these international goals are met would affect the cost of both H.R. 2454 and S. 1733 in much more substantial ways than any differences in the bills themselves. The tighter caps assumed for other countries under the G8 agreement would increase their demand for GHG abatement, and thus raise the price for international offset credits. Adopting these new assumptions about international action would likely raise EPA's projected price of international offsets by approximately one quarter, and also significantly reduce the amount of international offsets purchased domestically. This increase in the price of international offsets would also result in an equivalent increase in domestic allowance prices. Note that more aggressive international action, while raising the cost of the U.S. climate policy, also benefits the U.S. because it leads to more global greenhouse gas reductions, resulting in smaller increases in temperature. Additionally, seriously engaging our trade partners, as envisioned in the G8 statement, embodied in U.S. international climate policy, and reflected in the latest modeling analyses, should decrease estimated leakage impacts.

Distributional Impacts

The way in which allowances are allocated (auctioned or given away) and how any revenues are used affect the distribution of costs of a GHG cap-and-trade policy across households. For example, the free distribution of allowances to firms tends to be very regressive: higher income households are less affected and may even be made better off, while lower income households could be worse off under a policy that distributes most or all allowances to industry. This is because the asset value of the allowances flow to households in the form of increased stock values or capital gains, which are concentrated in higher-income households. Revenues can also be redistributed in the form of lower payroll or corporate taxes. Such methods of distributing allowances can lower the overall cost of the policy by reducing distortions in the economy due to taxation. However, they may also be regressive because corporate tax reductions benefit higher-income households, and the lowest-income households do not pay federal income taxes (though an approach that uses a combination of income tax reductions and per-capita rebates can be designed to be progressive). Auctioning allowances with per-capita lump-sum distribution of revenues to households is often the least regressive cap-and-trade policy analyzed and is usually shown to be progressive.

Several recent cap-and-trade proposals (including H.R.2454 and S.1733) attempt to attenuate costs to households by allocating a percentage of allowances to consumers for free via local electricity distribution companies (LDCs). Because these allowances are allocated on the basis of electricity use, industrial, commercial, and residential consumers will benefit from electricity prices being kept low. However, this form of allowance allocation can dampen the price signal that induces consumers to conserve electricity, which increases the economy-wide cost of complying with the cap since greater emission reductions have to be achieved by other sectors of the economy. While electricity prices do not rise as much with LDC allocations, consumers will face higher prices for other energy-intensive goods and services.

The models EPA uses to analyze the costs of the policy assume there is one representative household, so distributional implications cannot be assessed directly within the general equilibrium framework. However, two recent studies have examined the incidence of costs across income classes of the cap-and-trade program in H.R.2454, which is similar in stringency and in the allocation of allowance value to S.1733 (CBO, 2009; Blonz and Burtraw, 2009). Before accounting for the way in which allowances are allocated or revenues are redistributed, these analyses show that the cap imposes higher welfare costs (as a percentage of household income) on lower income deciles. This is an expected result since lower income households spend a higher fraction of their incomes on energy-intensive goods.

Accounting for the distribution of allowance value counteracts some of the welfare costs for all households and presents a different picture of the net welfare impacts of the policy across income groups. Both of these studies find an inverted U-shaped relationship between net welfare loss and income: lower income households are on net better off than without the policy and the wealthiest households bear a smaller burden or are virtually unaffected by the policy. The highest costs as a percentage of income are borne by middle to upper-middle income households.

For example, Blonz and Burtraw (2009), account for 56 percent of emissions allowances in H.R.2454, including allowance value that is allocated to electricity and natural gas LDCs, home heating oil providers, and low-income families, find that in 2015 the benefit of these allowance allocation approaches more than offset the higher cost of goods and services resulting from the policy for households in the bottom two income deciles. The third and tenth income deciles experience a smaller net cost than the average household under the policy. It is the households in the middle to upper-middle income deciles that bear the highest costs as a portion of household income. A full accounting of allowance allocation would likely exacerbate the overall regressiveness of the policy since the undistributed allowance allocations are primarily allocations to industry, which will tend to benefit shareholders, most of whom are in the upper income deciles.

The Congressional Budget Office accounts for a great share of the distribution of emission allowances and finds qualitatively similar results in their analysis of H.R. 2454. CBO (2009) estimates the loss in purchasing power[20] that would be faced by households in each fifth (quintile) of the population arrayed by income (and adjusted for household size). In 2020,

gain of about 0.7 percent of after-tax income, or about $125 measured at 2010 income levels. The largest loss would be experienced by households in the middle and fourth income quintile, about 0.5-0.6 percent of income, or about $310-375 at 2010 income levels. Households in the highest income

[20] CBO calculates the loss in purchasing power as the costs of complying with the policy (including the cost of purchasing allowances and offsets, and of reducing emissions—costs that businesses would generally pass along to households in the form of higher prices) minus the compensation that would be received as a result of the policy.

quintile would see a small *loss* [21]

Different methods of distributing the allowance value will yield different distributional results. For example, Blonz and Burtraw (2009) compare their analysis of H.R. 2454 to an alternative allocation of the same 56 percent of allowances in which the allocation to LDCs is limited to residential consumers of electricity and natural gas. The proposed allocation scheme on behalf of residential electricity and natural gas customers accounts for approximately 15 percent of allowance value, leaving the remaining 41 percent to be distributed as a per-capita dividend. They find this alternative would smooth out the burden across households while simultaneously lowering the overall costs for households in the third through ninth income deciles. The bottom two income deciles are still better off than in the no policy case.

Analyzing a policy similar in stringency to H.R. 2454 and S. 1733, Burtraw et al. (2009) find that if all of the allowances are auctioned and returned to consumers as a nontaxable dividend, the bottom three income deciles are on net better off than without the policy. The majority of costs as a portion of household income are born by households in the sixth to tenth income deciles. They also note that if the lump sum rebate were taxable, the policy would be more progressive. This is because, assuming budget neutrality, the pre-tax lump sum rebate would be increased by the average income tax rate for all households. Poorer households would then hold a larger after-tax rebate than wealthier households.

If the rebate to low income households instead were redistributed on a lump sum non-taxable rebate across all households, the policy would be less progressive. While less progressive, it does have the feature that the net burden would be levelized across households on a percentage-of-income basis. If a greater share of the allowance value were returned to households based on their energy consumption rather than through a lump-sum rebate, the incidence model would likely show the overall policy cost would increase while the change in the distribution of costs is less clear.

EPA is currently developing the capacity to model the distributional impacts of the allowance allocations in existing bills using an incidence model and methodology similar to the one described in Burtraw et al. (2009).

Temperature Impacts

In previous analyses, EPA has looked at the impact of U.S. policy combined with the policies assumed for developed and developing countries on global greenhouse gas

[21] CBO goes on to show that H.R. 2454 would have different impacts across households in 2050, by which time most of the value of allowances would flow to households directly. There would be a larger gain in purchasing power (as a percentage of after-tax income) for the lowest income households and a larger loss for the highest income quintile compared to the middle income groups. The largest burden would still be experienced by households in the middle and next-to-highest income quintiles.

concentrations. However, the assumptions used in earlier analyses for what policies other countries would adopt are not consistent with the recent G8/Major Economies Forum goal discussed above. EPA has now analyzed, using the MiniCAM and MAGICC models, how U.S. targets consistent with the President's FY 2010 budget proposal (14% below 2005 in 2020, and 83% below 2005 in 2050)[22] combined with international action consistent with the G8 agreement could affect global CO_2e concentrations and temperatures.

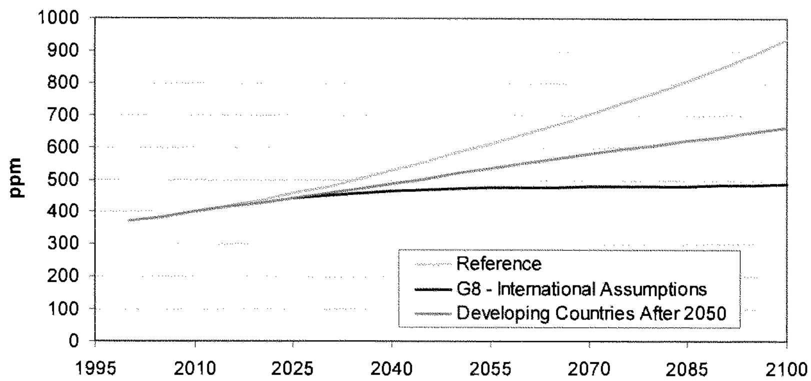
Figure 5 below shows global CO_2e concentrations through 2100 assuming a climate sensitivity (CS) of 3.0.[23] The CS is the equilibrium temperature response to a doubling of CO_2, and a CS of 3.0 is deemed the "best estimate" by the IPCC.[24] The figure presents three scenarios:

(1) Reference: no climate polices or measures adopted by any countries.
(2) G8 - International Assumptions: consistent with G8 agreement to reduce global emissions to 50% below 2005 levels by 2050. U.S. and other developed countries reduce emissions to 83% below 2005 levels by 2050, and developing countries cap emissions beginning in 2025, and return emissions to 26% below 2005 levels by 2050. All countries hold emissions targets constant after 2050.
(3) Developing Countries After 2050: US and developed countries same as G8 scenario. Developing countries adopt policy in 2050 holding emissions constant at 2050 levels.

In the reference scenario, CO_2e concentrations in 2100 would rise to approximately 936 ppm.[25] If the U.S. and other developing countries took action to reduce emissions to 83% below 2005 levels by 2050, and developing countries took no action until 2050, then CO_2e concentrations in 2100 would rise to approximately 647 ppm. If the G8 goals are met, then CO_2e concentrations would rise to approximately 485 ppm in 2100. It should be noted that CO_2e concentrations are not stabilized in these scenarios. To prevent concentrations from continuing to rise after 2100, post-2100 GHG emissions would need to be further reduced. For example, stabilization of CO_2e concentrations at 485 ppm would require net CO_2e emissions to go to zero in the very long run after 2100.

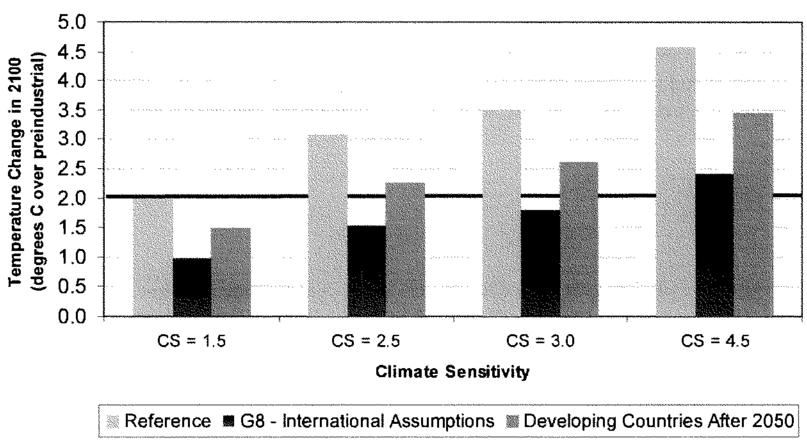
[22] The cumulative GHG emissions under the cap from 2012 – 2050 under the President's FY 2010 budget proposal are 133.9 $GtCO_2e$. This is 1% greater than the 132.6 $GtCO_2e$ in H.R. 2454, and 2% greater than the 130.6 $GtCO_2e$ in S. 1733.
[23] The climate sensitivity is the equilibrium change in global mean near-surface air temperature that would result from a sustained doubling of the atmospheric CO_2e concentration.
[24] IPCC WG1 SPM (2007): "[Climate sensitivity] is *likely* to be in the range
2°C to 4.5°C with a best estimate of about 3°C, and is *very unlikely* to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded..."
[25] Global CO_2 concentrations in 2008 were 385.6 ppmv (see Tans (2009)) compared with pre-industrial concentrations of 280 ppmv (see IPCC WG1 SPM (2007)). According to the IPCC, historic CO_2 concentrations have not exceeded 300 ppmv in the last 650,000 years.

Figure 5 – CO_2e Concentrations (Climate Sensitivity = 3.0)



Given the CO_2e concentrations for the various scenarios, we can also calculate the observed change in global mean temperature (from pre-industrial time) in 2100 under different climate sensitivities. Assuming the G8 goals (reducing global emissions to 50% below 2005 by 2050) are met, warming in 2100 would be limited to no more than 2 degree Celsius (3.6 degrees Fahrenheit) above pre-industrial levels under a climate sensitivity of 3.0 or lower, as shown in figure 6 below.

Figure 6 – Global Mean Temperature Change in 2100 by Scenario and Climate Sensitivity (CS)



It should be noted that the temperature change in 2100 in this scenario is not stabilized, so the observed change in global mean temperature in 2100 is not equal to the equilibrium change in global mean temperature. There are two reasons for this. First, while the G8 international goals stabilize global GHG emissions at 50% below 2005 levels, CO_2e concentrations and temperature are not stabilized. Determining an equilibrium temperature under any scenario requires additional assumptions about post-2100 emissions. If emissions remain constant post-2100, CO_2e concentrations will continue to rise. Equilibrium temperature would only be achieved after CO_2e concentrations are in equilibrium. Second, the inertia in ocean temperatures causes the equilibrium global mean surface temperature change to lag behind the observed global mean surface temperature change by as much as 500 years. Even if CO_2e concentrations in 2100 were stabilized, observed temperatures would continue to rise for centuries before the equilibrium were reached.

Continued GHG emissions reductions after 2100 could stabilize CO_2e concentrations at the 485 ppm levels achieved in 2100 in the G8 scenario. In order to achieve an equilibrium temperature change of 2 degrees (assuming CS = 3.0), CO_2e concentrations must be stabilized below 485 ppm, requiring continued abatement beyond the level needed to stabilize concentrations at 2100 levels. It would be possible to reduce CO_2e concentrations after 2100 below 485 ppm by even further reducing GHG emissions in the next century. An 'overshoot' scenario such as this would further reduce the equilibrium temperature change, making it possible to achieve the 2 degrees C target even with a climate sensitivity of 3.0.

While this analysis doesn't quantify the impacts of higher temperatures and other effects of increasing GHG concentrations, the U.S. Global Change Research Program (in its June 2009 report, "Global Climate Change Impacts in the United States") described the impacts that we are already seeing and that are likely to dramatically increase this century if we allow global warming to continue unchecked. In the report, it documents how communities throughout America would experience increased costs, including from more sustained droughts, increased heat stress on livestock, more frequent and intense spring floods, and more frequent and intense forest wildfires.

Conclusion

EPA's analysis of S. 1733 demonstrates that the costs of the bill are likely to be quite similar to the costs of H.R. 2454. While there are some minor differences in the bills in several areas that will likely result in slightly higher costs for S. 1733, these differences are overshadowed by the fundamental similarities in approach, caps, offsets, and other critical design parameters that affect the costs.

In table 5 below, we depict the differences between the bills with respect to these fundamental design parameters and illustrate for each element the degree to which we expect similarities or differences in the costs of S. 1733 compared to H.R. 2454. The evidence for the finding in the table is drawn from the preceding text in this paper, which clearly shows the large similarities between the two bills.

Table 5: Summary of Impacts of Key Provisions in S.1733

Key Provisions	H.R. 2454	S. 1733	Impact of Differences in S. 1733 on Modeled Costs & Price from H.R. 2454
Cap Level	17% below 2005 in 2020; cumulative number of allowances are 132.2 gigatons CO_2e	20% below 2005 in 2020; cumulative number of allowances are 130.6 gigatons CO_2e	Small increase in both allowance prices and costs
Coverage	Differences are negligible		
Offset Limits	2 billion ton limit overall; 1 billion ton domestic limit; 1 billion ton international limit; Up to an extra 0.5 billion tons of international offsets if domestic usage below 0.9 billion tons	2 billion ton limit overall; 1.5 billion ton domestic limit; 0.5 billion ton international limit; Up to an extra 0.75 billion tons of international offsets if domestic usage below 0.9 billion tons	Negligible, or small increase in both allowance prices and costs in low technology scenarios
Strategic Reserve	2.7 billion cumulative allowances from 2012-2050. Minimum reserve auction price is 60 percent above the 36-month rolling average of that year's emissions allowance vintage	3.5 billion cumulative allowances from 2012-2050. Minimum reserve auction price is \$28 in 2012 rising at 5% through 2017 and rising at 7% thereafter.	Small increase in both allowance prices and costs if minimum reserve prices are not met Changed conditions on minimum reserve auction price have the potential to provide better price certainty.
Energy Efficiency and Renewable Energy Provisions	Building codes, energy efficiency-related allocations, and Combined Efficiency and Renewable Energy Standard	Less stringent building codes, slightly lower energy efficiency-related allocations, and no Combined Efficiency and Renewable Energy Standard	Slight increase in allowance prices due to changes in energy efficiency provisions; a decrease in costs and price without the renewable energy requirements is possible to the extent that such requirements are binding in H.R. 2454
Performance Standards	Standards for uncapped sources (e.g., landfills, coal mines, and natural gas systems)	Uncapped sources treated as domestic offsets	Small decrease in both allowance prices and costs, though U.S. cumulative emissions increase slightly
CCS Bonus	5.32 billion allowances, fixed incentive for first 6 GW, reverse auction thereafter	4.19 billion allowances, fixed advanced payment incentive for first 20 GW, reverse auction thereafter	Small increase in allowance prices due to smaller bonus allowance pool
Energy Intensive, Trade Exposed Industries	Differences are negligible		
Transportation	Differences are negligible		
Domestic Agriculture and Forestry Offsets	Differences are negligible		

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Appendix

Past EPA modeling analyses of Bills related to mitigating greenhouse gas emissions

Since 2005, EPA has released six analyses, including three for the 110^{th} Congress. This appendix provides a list of the analyses, a brief description of the scenarios modeled for each, and a brief description of the models used for these analyses.

It is important to note that EPA is not alone in performing economic analyses of climate legislation. Within the U.S. government, the Energy Information Administration and the Congressional Budget Office have done analyses of recent legislative climate policy proposals. USDA has also developed analysis related to the role of agriculture in climate policy proposals. Outside of the U.S. government the Stanford Energy Modeling Forum has gathered together a number of models that have been widely used for climate policy analysis including: the Applied Dynamic Analysis of the Global Economy model (ADAGE) from the Research Triangle Institute; the Emissions Predictions and Policy Analysis model (EPPA) from the Massachusetts Institute of Technology; the Model for Emissions Reductions in the Global Environment (MERGE), from the Electric Power Research Institute; MiniCAM, from the Pacific Northwest National Laboratory / Joint Global Change Research Institute; the Multi-Region National Model - North American Electricity and Environment Model (MRN-NEEM), from Charles River Associates; and the Intertemporal General Equilibrium Model (IGEM), from Dale Jorgenson Associates (Fawcett *et al.*, forthcoming).

Analyses:

- **Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009 – June 2009**
- **Preliminary Analysis of the Waxman-Markey Discussion Draft in the 111th Congress, The American Clean Energy and Security Act of 2009 – April 2009**
- **Analysis of Senate Bill S.2191 in the 110th Congress, the Lieberman-Warner Climate Security Act of 2008 – March 2008**
- **Analysis of Senate Bill S.1766 in the 110th Congress, the Low Carbon Economy Act of 2007 – January 2008**
- **Analysis of Senate Bill S.280 in the 110th Congress, The Climate Stewardship and Innovation Act of 2007 - July 2007**
- **Analysis of Senate Bill S.843 in the 108th Congress, Clean Air Planning Act - October 2005**

Note: The "Waxman-Markey Discussion Draft" and H.R. 2454 were analyzed with updated models reflecting, among other changes, the AEO March 2009 reference case *which reflects the provisions of the Energy Independence and Security Act of 2007, but not those of the American Recovery and Reinvestment Act of 2009.*

Scenarios Analyzed:

Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009 – June 2009

1) EPA 2009 Reference Scenario
2) H.R. 2454 Scenario
3) H.R. 2454 Scenario without Energy Efficiency Provisions
4) H.R. 2454 Scenario with Output-Based Allocations
5) H.R. 2454 with Reference growth in Nuclear Power
6) H.R. 2454 Scenario without Output-Based Allocations or Energy Efficiency Provisions
7) H.R. 2454 Scenario without International Offsets

Preliminary Analysis of the Waxman-Markey Discussion Draft in the 111th Congress, The American Clean Energy and Security Act of 2009 – April 2009

1) EPA 2009 Reference Scenario
2) Waxman-Markey Scenario
3) Waxman-Markey Scenario with Energy Efficiency Provisions
4) Waxman-Markey Scenario with Output-Based Allocations
5) Waxman-Markey Scenario with No International Offsets

Analysis of Senate Bill S.2191 in the 110th Congress, the Lieberman-Warner Climate Security Act of 2008 – March 2008

1) EPA Reference Scenario
2) S. 2191 Scenario
3) S. 2191 Scenario with Low International Action
4) S. 2191 Scenario Allowing Unlimited Offsets
5) S. 2191 Scenario with No Offsets
6) S. 2191 Scenario with Constrained Nuclear and Biomass
7) S. 2191 Scenario with Constrained Nuclear, Biomass, and Carbon Capture and Storage
8) S. 2191 Scenario with Constrained Nuclear, Biomass, Carbon Capture and Storage, international targets "Beyond Kyoto" and a Natural Gas Cartel
9) Alternative Reference Scenario, assuming EIA "High Technology" case
10) S. 2191 Alternative Reference Scenario

Analysis of Senate Bill S.1766 in the 110th Congress, the Low Carbon Economy Act of 2007 – January 2008

1) Core Reference Scenario
2) S. 1766 Scenario
3) S. 1766 Scenario without Technology Accelerator Payments (TAP)
4) S. 1766 Scenario with Ten Percent International Offsets
5) S. 1766 Scenario with Unlimited International Offsets
6) S. 1766 Scenario without TAP, and with Ten Percent International Offsets
7) S. 1766 Scenario without TAP, and with Unlimited International Offsets
8) S. 1766 Scenario without Carbon Capture and Storage Subsidy
9) S. 1766 Scenario without Tap, and with no Carbon Capture and Storage Subsidy
10) S. 1766 Scenario without Carbon Capture and Storage Subsidy and Low Nuclear
11) S. 1766 Scenario with Alternative International Action
12) High Technology Reference Scenario
13) S. 1766 High Technology Scenario
14) S. 1766 High Technology Scenario without TAP
15) S. 1766 High Technology Scenario with Ten Percent International Offsets
16) S. 1766 High Technology Scenario with Unlimited International Offsets
17) S. 1766 High Technology Scenario without TAP, and with Ten Percent International Offsets
18) S. 1766 High Technology Scenario without TAP, and with Unlimited International Offsets
19) S. 1766 High Technology Scenario without Carbon Capture and Storage Subsidy
20) S. 1766 High Technology Scenario without TAP, and without Carbon Capture and Storage Subsidy

Analysis of Senate Bill S.280 in the 110th Congress, The Climate Stewardship and Innovation Act of 2007 - July 2007

1) EPA Reference Scenario
2) S. 280 Senate Scenario
3) S. 280 Senate Scenario with Low International Action
4) S. 280 Senate Scenario allowing Unlimited Offsets
5) S. 280 Senate Scenario with No Offsets
6) S. 280 Senate Scenario with Lower Nuclear Power Growth
7) S. 280 Senate Scenario with No Carbon Capture and Storage

Analysis of Senate Bill S.843 in the 108th Congress, Clean Air Planning Act - October 2005

Note S. 843 was a bill addressing emissions from the power sector, and not an economy-wide approach like those above. The bill set a cap for carbon dioxide emissions from the power sector and allowed for domestic and international offsets to meet the cap. EPA analyzed those provisions of the bill with early versions of the models used for the analyses listed previously. A number of sensitivities were performed for the power sector components, but for the GHG analysis, only two scenarios were analyzed.

1) Core Scenario – assuming Kyoto ends in 2012
2) Sensitivity Scenario – assuming Kyoto continues with no changes

Models Used

Applied Dynamic Analysis of the Global Economy Model (ADAGE)

ADAGE is a dynamic computable general equilibrium (CGE) model capable of examining many types of economic, energy, environmental, climate-change mitigation, and trade policies at the international, national, U.S. regional, and U.S. state levels. ADAGE is developed and run for EPA by RTI International. See the model homepage at http://www.rti.org/adage

Intertemporal General Equilibrium Model (IGEM)

IGEM is a model of the U.S. economy with an emphasis on the energy and environmental aspects. It is a dynamic model, which depicts growth of the economy due to capital accumulation, technical change and population change. IGEM is a detailed multi-sector model covering 35 industries. The model is developed and run by Dale Jorgenson Associates for EPA. See the model homepage: http://post.economics.harvard.edu/faculty/jorgenson/papers/papers.html

Non-CO_2 Greenhouse Gas Models

EPA develops and houses projections and economic analyses of emission abatement through the use of extensive bottom-up, spreadsheet models. These are engineering–economic models capturing the relevant cost and performance data on over 15 sectors emitting the non-CO_2 GHGs. The data used in the report are from *Global Mitigation of Non-CO_2 Greenhouse Gases* (EPA Report 430-R-06-005). www.epa.gov/nonco2/econ-inv/international.html

Forest and Agricultural Optimization Model – GHG (FASOM-GHG)

FASOM-GHG simulates land management and land allocation decisions over time to competing activities in both the forest and agricultural sectors. In doing this, it simulates the resultant consequences for the commodity markets supplied by these lands and, importantly for policy purposes, the net greenhouse gas (GHG) emissions. FASOMGHG is a multiperiod, intertemporal, price-endogenous, mathematical programming model depicting land transfers and other resource allocations between and within the agricultural and forest sectors in the US. The principal model developer is Dr. Bruce McCarl, Department of Agricultural Economics, Texas A&M University. The data used in the report are documented in: U.S. EPA, 2009. *Updated Forestry and Agriculture Marginal Abatement Cost Curves.* Memorandum to John Conti, EIA, March 31, 2009. See the model homepage: http://agecon2.tamu.edu/people.faculty/mccarl-bruce/FASOM.html

Global Timber Model (GTM)

GTM is an economic model capable of examining global forestry land-use, management, and trade responses to policies. In responding to a policy, the model captures afforestation, forest management, and avoided deforestation behavior.
The model is a partial equilibrium intertemporally optimizing model that maximizes welfare in timber markets over time across approximately 250 world timber supply regions by managing forest stand ages, compositions, and acreage given production and land rental costs. The principal model developer is Brent Sohngen, Department of Agricultural, Environmental, and Development Economics, Ohio State University. See the model website for GTM papers and input datasets:
http://aede.osu.edu/people/sohngen.1/forests/ccforest.htm#gfmod

Global Climate Assessment Model (GCAM, formerly MiniCAM)

The MiniCAM is a highly aggregated integrated assessment model that focuses on the world's energy and agriculture systems, atmospheric concentrations of greenhouse gases (CO_2 and non-CO_2) and sulfur dioxide, and consequences regarding climate change and sea level rise. The model is developed and run at the Joint Global Change Research Institute, University of Maryland. See the model homepage:
http://www.globalchange.umd.edu

Integrated Planning Model (IPM)

EPA uses the Integrated Planning Model (IPM) to analyze the projected impact of environmental policies on the electric power sector in the 48 contiguous states and the District of Columbia. IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. The IPM was a key analytical tool in developing the Clean Air Interstate Regulation (CAIR) and was also used in the development of the Regional Greenhouse Gas Initiative (RGGI). The model was developed by ICF Resources and is applied by EPA for its Base Case. IPM® is a registered trademark of ICF Resources, Inc. EPA's application of IPM Homepage:
http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html

Senator BOXER. But I thank you all, and we will go now to Senator Gillibrand.

Senator GILLIBRAND. Thank you, Madam Chairwoman, and thank you witnesses for being here. Your testimony is very important to this national debate, and I am very grateful for your leadership and opinions and sharing your expertise with all of us.

I would like to direct my conversation, initially, to Mr. Law. I would like it if you could please describe for me, for the panel, and for our attendees the kind of work that you are doing for your customers as part of the Efficiency Long Island Program and how energy efficient investments are saving your customers money by reducing energy consumption.

Mr. LAW. Thank you very much, Senator Gillibrand. Our Efficiency Long Island Program, as I said, is about a $1 billion program over the next 10 years.

We have had a new base load power plant on Long Island that just came on line this year. It cost $1 billion. And now it will have to be fed fossil fuels for the next 30 years to operate. I would rather invest the next $1 billion, and give it back to our customers, in the form of helping them become smarter with the energy that they use.

We do that in the form of rebates to help them buy Energy Star appliances, lighting appliances, pool motors, furnace motors, air conditioning units, dehumidifiers, things like that. The goal there is to help them lower their consumption and lower their bills. When they lower their consumption, that allows us to reduce our peak demand. And the goal of the program, for LIPA, is to avoid having to build that next power plant.

So, it helps LIPA, it helps the customer in terms of lower bills. And again, we find that it is not only the right thing to do, but trying to site a power plant, nobody wants one in their backyard, and then trying to finance it, and then having to deal with the emissions, and then having to feed it fossil fuels, are all challenges.

We find it is better to help our customers become smarter with the energy they use, and that is the goal and the purpose of Efficiency Long Island.

Senator GILLIBRAND. Thank you. Mr. Keohane, can you discuss how prioritizing efficiency in the utility sector would benefit customers nationwide, and do you believe that a minimum requirement for efficiency would enhance the consumer protection from this legislation?

Mr. KEOHANE. Thank you, Senator. I think, first of all, it has been shown time and again through, I think, a variety of very successful programs across the country that wise, smart investments in cost effective energy efficiency can be very effective ways of reducing consumers' bills. I think there are also ways that consumers can take advantage of those common sense approaches.

I think in terms of the—in the context of allowance allocation, I think the most important principle is that the value go to those consumers for their benefit, and if it can be shown that the best way to do that is cost effective energy efficiency investments, as we have seen in some areas in the past, I think that is terrific.

But I would say the bedrock principle there is just make sure that allowance value does protect the consumers and that it goes to their benefit.

Senator GILLIBRAND. Thank you. Now, for Mr. Crane, and this is for the whole panel, can you discuss the development of utility scale renewable projects and your thoughts on the potential growth of large scale projects in the next decade?

Mr. CRANE. Well, I think right now, as much as this Administration has tried to stimulate renewable projects, the absence of a tax appetite, the dropping of fossil fuel prices, and the absence of financing from Wall Street, which has not really recovered as you all know from your State, makes large scale renewable projects very, very difficult, and quite frankly, the Department of Energy Loan Guaranty Program right now is critical.

Our company is hoping to build what would be the largest solar thermal project in Senator Udall's State, but without the—because the technology is emerging and all those other problems, without the loan guaranty from the DOE, it is just not going to happen.

So, it is a challenging environment. But our company, Mr. Izzo's company, many companies are pursuing these projects in the hope that we can overcome all of these. So, we are all hard at work at this.

Mr. IZZO. Senator, the primary obstacle to growing renewables is the fact that the current technology just is not competitive with the current market price for electricity. By having a cap and trade system, you will more accurately reflect long-term costs. That gap will narrow.

Having said that, that will then lend itself to large scale renewable development in certain parts of the country. Absent a national renewable portfolio standard, you will not see growth in renewables. Therefore, it is no surprise that over 70 percent of the renewables that have been installed in the last 2 years in this country have been in those States with renewable portfolio standards.

Senator GILLIBRAND. Anyone else before my time——

Mr. HART. I might say the electric cooperatives nationwide have set up what they call a National Renewable Energy Cooperative, and the idea there is to pool resources to see if we can tap into some of the expertise in Missouri on wind, and New Mexico, co-ops down there doing the solar, if we can pull all those folks together and come up with a national initiative.

But the investment tax credits are a huge catalyst to getting financing for renewable energy, and I have heard a lot of the wind developers tell me that if we could just get those investment tax credits extended for a longer period of time, it is going to make it easier for them to finance them. So, that is something you might want to consider.

Senator GILLIBRAND. Thank you.

Senator BOXER. Thank you.

Senator Bond.

Senator BOND. Thank you, Madam Chair, and my good friend Barry. I apologize. I have a couple of other committees that I have to work on.

I want to straighten out a few things, Madam Chair. I made a mistake yesterday when I said your bill would provide $16 billion less than Waxman-Markey. When we now have had an opportunity to review the targets, and how it operates, we now see that it does not provide 35 percent of the program allowances. This is what Waxman-Markey provides.

But when you take a number of slices out of the pie, it is a smaller pie. And so we have $1.46 billion fewer allowances, and that means that there will be a shortfall of about $4.4 billion allowances. Multiplying that by the estimated price per allowance reveals a $133 billion shortfall. If it is complicated, it is taking us some time to analyze——

Senator BOXER. I will give you some more time. I will give you another minute. If I am going to give you a minute, I just want you to understand that that went in to the Deficit Reduction Trust Fund. So, that was the reason we did the haircut.

But the pie, in terms of the percentages, remained the same. But we did have to take across-the-board cuts for deficit reduction, and they only went out 10 years. We went out to 2050 and we wanted to have a deficit neutral bill.

But you are absolutely right on the point. You are absolutely correct. There is less in there because of Deficit Reduction Trust Fund. But go ahead. We will add a minute to you.

Senator BOND. OK. I wanted to add another point that we talked about cap and trade. You said that it worked for acid rain. I happened to be the lead Republican sponsor on the Byrd-Bond amendment, some people back home call it the Bond-Byrd amendment. That worked because we had a ready solution to acid rain production.

There is no affordable technology ready to remove carbon from coal and sequester it. 2020 is what Secretary Chu said. With no low carbon type of coal, the main strategy Missouri utilities would have to use to meet the mandates here would be to move more production to nuclear power. And Barry, if Missouri power generators are forced to switch from coal to natural gas, what would that do to power rates in Missouri?

Mr. HART. Under that study that I talked about earlier, it is the worst case scenario. If we switch to natural gas, you are looking at by 2012, 46 percent and by 2020, 77 percent. So that is the worst case scenario for our State.

Senator BOND. How would your co-op members react if Congress passes this legislation that really burdens coal dependent regions like the Midwest?

Mr. HART. They may not be very happy, and I might not be back here next year. I am not sure.

Senator BOND. What I really worry about is how do you think employers in Missouri would react to the higher power bills? Would you see some of the smaller businesses that are energy intensive moving out of the region?

Mr. HART. That is a hard one to factor in. But I know businesses that—we are in a recession right now, so it is tough for small business. One thing we know, too, in Missouri is a lot of our small businesses are the entities that create the jobs.

Senator BOND. Well, I think everybody knows that small business is the job producing core, and we seem to be steamrolling small businesses in a lot of things that we are doing up here. That is why it worries me.

We previously submitted a study from the Food and Agricultural Policy Research Institute and the University of Missouri working with Iowa State and others. It said that a farmer, a row crop farmer of corn and soy beans, 1,900 acres, would see $11,000 cost initially going to $32,000. I imagine a significant number of your customers are row crop farmers. What would that do if you put that extra burden on their operations? Would they stay in business, or would they be hard pressed to make ends meet?

Mr. HART. I think they are going to be hard pressed. But I know the one segment that I have heard from a lot is the dairy industry. Their difficulty is that they are very energy intensive——

Senator BOND. Right. I think ATTRA is doing a study on dairy and livestock, and this would be, I assume, equally devastating to them. We have a lot of sources we can use. The point I have been making is we can reduce emissions, but we cannot do so if people are losing their jobs and cannot afford to buy power.

We have a lot of biomass in Missouri. Some six-sevenths of our 14 million of timber is scrub timber. You can burn that with coal. But to do that, you have to stay in business. And obviously we need more nuclear in Missouri. I assume when working with the other utilities you are looking for these cleaner energy solutions, and for Missouri it seems to me that the wind does not blow very frequently except in Jefferson City when the General Assembly is in session. I would think that biomass would a better—pardon, nuclear would be a better source for you. What is your view on it?

Mr. HART. Well, first of all I want to make sure everyone knows that I did not say that about Jefferson City.

[Laughter.]

Senator BOND. I did.

Mr. HART. Yes. You can get away with it. But I just think that if Senators can work to minimize this impact on consumers, whether they are residential, the elderly on fixed incomes, I was telling them, Senator, that one-third of our membership is Missouri is over 65——

Senator BOND. A lot of us are.

Mr. HART. And 80 percent of those are on fixed income. If we can work all of these different segments, people that are using electricity in this country, we might be able to come up with policy that is going to be successful.

Senator BOND. Thank you.

Mr. HART. But the consumers have to support it.

Senator BOND. Thank you, Madam Chair.

Senator BOXER. Yes. And speaking of senior citizens, AARP sent us a letter. I am going to put it in the record. They are excited about the possibilities here.

[The referenced letter was not received at time of print.]

Senator BOXER. Senator Lautenberg.

Senator LAUTENBERG. Thanks, Madam Chairman. When you mentioned senior citizens, I was ready to take the microphone.

[Laughter.]

Senator BOXER. Well, I am one as well.

Senator LAUTENBERG. I am sorry that I was late in arriving. We have a couple of other committees that are meeting at the same time.

But I did want to welcome Ralph Izzo here. He is the Chief Executive of Public Service Electric and Gas and has been a real leader in terms of understanding the needs of the community, but understanding also that you have to communicate with the customers and let them know what we are about.

And it has resulted in a really nice relationship even though people understand that there is going to have to be some extra money spent. And we hate to see it. Recession is really still very heavily among working people, and job loss is not something that we face lightly. But the fact of the matter is that we are where we are.

Mr. Izzo, what has been the response from your customers to the aggressive actions that PSEG has done, whether it has been distributing light bulbs, whether it is pleading for a more careful use, et cetera?

Mr. IZZO. We survey our customers once a quarter on how we are doing, how quickly we are answering the phone, how do you like what we are doing in terms of community outreach, and we get consistently high marks from customers for our aggressive actions in promoting renewable energy sources and energy efficiency.

In addition to that, the extra benefit that I, quite candidly, did not anticipate is the enormous pride our employees feel at being active in the community and now being viewed not as the electric company and the monopoly, but someone who is trying to preserve the planet for their children and their grandchildren.

Senator LAUTENBERG. You know, we have the good fortune in New Jersey to be on the coast. It is a wonderful coast. But the fact is that we are to the east of States that have a lot of material being sent up into the air from coal burning plants, et cetera. So, there is some imbalance.

Mr. Johnson, I kind of look to you when I say that. And no one needs lecture the other party. But I will tell you this. When South Dakota had floods and terrible things happening, we were there to help them through a natural disaster. And so it is at this time. And while it does, when you say it, it sounds terrible, we should not have to penalize one State to get to another.

But in the distribution of expected increases in costs, New Jersey looks like it might be $3, South Dakota $5 a month. It is not pleasant to contemplate. People with modest incomes feel those kinds of things very seriously.

So, I would urge you to look at this and see what kind of—to use the cliché around here that says, what goes around comes around. There are very few States that have not, at some time or other, been there with their hand out, with a plea for the Federal Government, please, come help us, move our citizens away from flooded areas, et cetera, et cetera. So we are all in this together.

And we also know one other thing. I will reduce my philosophizing in a minute when the clock hits over here. But the fact of the matter is we have a sick patient. This patient is not strong. This patient is weak. The patient needs medicine. The medicine tastes terrible. But that is the condition that the country is in. We are still in recession, we are overrun by inadequate infrastructure development, et cetera.

But if we are called upon, we all spring together to put on a uniform as I did a long time ago, and you do what you have to. I am not telling you what kind of message to give to the South Dakotans, but the fact of the matter is there may be a little imbalance here, but we are all looking for the same outcome, and that is a safer place for our children to grow, for our plants, for our wildlife, so that we can breathe the air and enjoy life.

Thanks, Madam Chairman.

Senator BOXER. Thank you.

Senator Udall.

Senator UDALL. Thank you, Madam Chair. Mr. Bluestein, your testimony notes that the major recent supply increases of natural gas provide us with a powerful option to reduce greenhouse gas emissions with a widely available fuel using existing infrastructure.

In the climate debate, there has been concern that fuel switching would cause natural gas prices to increase for manufacturers and fertilizer to increase for farmers. Are these fears based on an outdated understanding of the natural gas supplies that are now available in the U.S.?

Mr. BLUESTEIN. Yes, I think they are. As I said earlier, these new shale gas resources are really changing our fundamental understanding of North American gas supply. And they are really just starting to take off. As that resource was starting to take off, we had the economic downturn, and the demand for gas came down, and some of the drilling actually reduced because there was less demand.

So, I do not think we have really even yet seen the reality of how large this resource could be, and I think that will be good news for industrial gas users and feedstock industries like ammonia that rely on natural gas.

Senator UDALL. And could you give us an idea of the magnitude just in the last couple of years?

Mr. BLUESTEIN. In terms of the resource, you know, the National Petroleum Council in its study in 2003 estimated—let me just check my numbers—the shale resource at, I think, less than 100 TCF. We did a study, it was done really about 18 months ago, we estimated it at 385 TCF. The Potential Gas Committee, in its study that came out in June, estimated it at 616 TCF. So it is really growing by leaps and bounds. And as I said, I do not know if we have fully evaluated it yet.

Senator UDALL. Now, I understand that you have studied the impact of a proposal made by the American Natural Gas Association to enact a so-called Bridge Fuel Credit, a new emissions credit based upon additional use of natural gas to reduce greenhouse gas emissions. Could you explain how such a credit would work and what its impacts would be?

Mr. BLUESTEIN. Well, the idea of this proposal is to provide a credit for any entity that uses natural gas to reduce greenhouse gas emissions by increasing the use of natural gas relative to a higher emitting fuel. We did an analysis of that proposal for the American Natural Gas Alliance.

There were several steps. The first was to develop a baseline that is comparable to the EPA and EIA modeling as a reference case. We then added in an estimate of the increased gas supply that is available now. So, not surprisingly when you account for that additional supply, you find that gas consumption goes up, and gas prices go down, relative to the baseline.

We then added the incentives for increased gas use, and we found, again, moderate increase in gas consumption and a decrease in allowance prices relative to the baseline and a slight increase in gas consumption, about 6 percent, with the increased use of gas.

So, back to your first question. Using gas to reduce emissions in the near term, not a huge increase in gas prices and actually a decrease in the CO_2 allowance price as a result of the program.

Senator UDALL. And do you have any recommendations on where you think the best use of natural gas is? Is it in the transportation sector? Is it in the electric power sector?

Mr. BLUESTEIN. Yes, I think that, you know, one of the strengths of natural gas is that is has very wide applicability. It is a very clean fuel, and as I said in the beginning of my testimony, I think it can be used effectively throughout the economy, power generation, transportation, there is a great opportunity, direct use by consumers, and of course, it is an important feed stock.

So, I think in the past there has been a feeling that we have to decide, is it better to use it here or there. I think that the hope is, with the greater resource, we do not have to worry about that.

Senator UDALL. Thank you. And I thank the whole panel.

Mr. Crane, you mentioned that NRG was putting a plant in Dona Ana in Dona Ana County in New Mexico. And I just want to thank you for moving into the solar energy business and bringing it into southern New Mexico, and it is great to have you here today.

Thanks to the whole panel.

Thank you, Madam Chair.

Senator BOXER. Thank you. Unless a Republican shows up, we have Whitehouse, Carper and Cardin.

Senator Whitehouse.

Senator WHITEHOUSE. Thank you, Madam Chair.

Commissioner Johnson, you, in your testimony, let me read this, say that these bills all envision softening the impact to consumers by providing some of them to low and middle income rebates to pay their utility bills. But I do not want more Americans more dependent on the Federal Government to pay their utility bills. If we need to reduce carbon, then let us do it. Let us put that money toward energy efficiency and toward research and development.

I think you are onto a very, very good point. But I want to let you know about a particular glitch that you might not be aware of, which is that when the allowance revenues are returned to the local electric utility or utility distributing companies, if we in Congress take a further step of saying that this is where they should be spent, the wizards at the Congressional Budget Office have determined that that is an expenditure of money by the Federal Government that needs to be offset with new revenues to meet our pay goal requirements.

So, we are a little bit handcuffed here in Congress by CBO's scoring methodology so that when we take, let us say the round number is $1 billion. You put $1 billion back into the local distributing companies, no cost. You say, and you should spend half of it on efficiency, now we have to offset $500 million with revenues.

So, we are in a bit of a pickle. And I could not agree with you more about the direction you seek. I think the place to go is not back into the bill, because we will tell you that. The place to go is to your friends at NARUC and to your fellow utility commissioners.

Because you can say, in your ratemaking process, OK, fellows, you are getting all of this money coming in from the Federal Government for these purposes. We want you to come in and show us how it is going to work, and you can put them under pressure to make sure that efficiency and R&D is where it goes in a way that we really are inhibited from doing by these peculiar CBO constraints.

Mr. JOHNSON. Well, Senator, thank you very much for that clarification. I would agree that the State level is a fantastic place, really the best place to do energy efficiency. I do wonder if research and development are not better done at an national level. And I also wonder about nuclear.

Senator WHITEHOUSE. It could well be. I was really focusing on the efficiency part, and I feel that is very important.

Mr. JOHNSON. Well, I agree with you 100 percent. I do also really believe in nuclear; it is tough to overstate how important it is going to be if we are going to get to 83 percent carbon reduction by 2050.

Senator WHITEHOUSE. We have good—I think you will be happy with the way this comes out on nuclear. There is a new nuclear era coming, and we just need to make sure we do it right and that we work as hard as we can to have the nuclear byproducts be manageable and there is technology that allows them, in fact, ultimately to be used as fuel. And we need to make sure that we develop that because that is the hazard.

Mr. JOHNSON. Well, Senator, thank you very much. You do give me reason for optimism that it is going to get better because I think actually, right now, the nuclear title is rather weak. But I will take your word for it, and we will wait for better wording.

Senator WHITEHOUSE. The other question that I have is for Mr. Izzo and Mr. Law. You both run major utility operations. I cut my teeth as a new lawyer doing the public utility regulatory work for the Attorney General's Office in Rhode Island. And way back in the 1980s, we did the first conservation-based rates with what was then called Narragansett Electric and New England Electric System. Now it is all National Grid.

So I have been familiar for some time with the predicament that electric utilities are in when they make money by selling kilowatt hours, but we need to reduce those kilowatt hours and improve the fuel mix in ways that may be less immediately cost effective for the utilities.

There has been some disaggregation of the electric utility industry and to GenCos and DisCos and TransCos, and I am wondering what your advice is to us on the best way to structure the electric utility operating environment so that the conservation efforts can become a profit center. I think you have a vital role in conservation. I hope even the lead role. Does a ConsCo that goes along with the TransCos and DisCos and GenCos make sense, or can you just do it with the rate adjustments and rate neutrality?

Mr. IZZO. We are not huge fans of the rate neutrality approach. We think it makes sense, but we do not worry about that a lot. What we are trying right now in New Jersey that is working very well is that we have a $250 million program whereby a light bulb looks the same way on my P&L statement as a circuit breaker. So, we have redefined the assets that we can put into what is called our rate base and earn a profit on. And that is a home run for the customer and for our shareholders.

Senator WHITEHOUSE. Mr. Law.

Mr. LAW. Thank you, Senator. As the head of a public utility without shareholders and only rate payers, I almost think we have a little bit of a higher standard to strive for because we are not trying to show a profit. We are not-for-profit. So, not every decision we can make a cost-benefit case on. Sometimes we need to look at things as investments. And I think we need to be investing in diversifying the portfolio of fuels used in our system now and by encouraging our customers to become more efficient.

So, one of the ways we are doing that in the entire State of New York, for both the regulated utilities and the public utilities, is, you know, the concept of decoupling revenue recoupment because, at least for the investor-owned utilities, at the end of the day they need to cover their costs and show a profit. And if you are going to encourage all of your customers to use less energy while your costs are still fixed, you are going to lose money.

So, part of the incentives to get the utilities to be more aggressive in promoting renewables and efficiency is to allow them to recoup or decouple some of the moneys that they will likely lose.

Senator WHITEHOUSE. Thank you. I appreciate it, Madam Chairman. I look forward to working with you all.

Senator BOXER. Thank you.

Senator Carper.

Senator CARPER. John, thanks so much for being with us and not just today, because I know you have been with us before, and we appreciate your advice and counsel and your willingness to come back again today and subject yourself to this. Hopefully, it is not too bad.

Let me just start off by asking a question maybe of Mr. Izzo and Mr. Crane and Mr. Keohane. You pronounce your name Keohane, do you not?

Mr. KEOHANE. Keohane.

Senator CARPER. I asked five different people up here, and I got five different answers. But Nathaniel's right, is it not?

[Laughter.]

Senator CARPER. Just a question for each of you. I think, in the past, each of your organizations, I believe have supported the notion of multi-pollutant legislation. And I, as you may recall, have long supported a 4–P approach, I believe it just makes sense from a business perspective and a public health perspective as well.

We have had a fair amount of discussion about the wisdom, or lack thereof, of adding 3–Ps to the climate bill, sulfur dioxide, nitrogen oxide and mercury. And I would ask, if adding 3–P legislation in the form of an amendment to the climate bill does not slow momentum to passage, would you be supportive of a multi-pollutant approach?

Mr. CRANE. On behalf of NRG, we would support that. But we do not, I mean, you had a key condition there. I mean we think the urgency of climate change legislation, if it did slow it down, that would give us pause. But we support your 3–P legislation and leave it up to you as to how you actually get it through.

Senator CARPER. Fine. Thank you.

Mr. IZZO. Senator Carper, we have been, and remain, supporters of your 3–P legislation. It is an essential part of regulatory clarity for us going forward in our industry. I try to convince myself that I am a moderately OK CEO, but I will never try to convince myself that I am intelligent legislative strategist. So, I leave that decision to this committee. We would love to see it if it could, indeed, go right through with that.

Senator CARPER. OK. Thanks so much.

Mr. Keohane.

Mr. KEOHANE. Well, Senator, I know you have been a leader on this, and we would certainly, absolutely support a comprehensive approach, and I think we have long been behind a comprehensive approach to air pollution regulation. I think the priority for us is, right now, making sure we get a climate bill. And if we can also get the strong 3–P bill along with that or as part of that, and still move that climate bill and get that protection, I think that would be terrific.

Senator CARPER. All right. Thanks. Thanks very much.

I will go back to you, if I could, Mr. Izzo. I think you mentioned in your testimony that you support a 50-50 allocation distribution of local electric-local distribution company allowances. I am not sure what all is involved in striking that compromise within EI, but I just want to thank you. I know how hard we have struggled with it here. And for those of you who actually worked to deliver that baby, thank you very much.

But that is, I think, 50 percent distributed on historical emissions and 50 percent distributed on generation. That is correct, is it not?

Mr. IZZO. That is correct.

Senator CARPER. The 50 percent distributed based on generation, which we also know affectionately as output, would greatly help nuclear energy. Is that correct?

Mr. IZZO. That is correct to the extent that you are selling into a competitive market.

Senator CARPER. Would you elaborate on that, please?

Mr. IZZO. Well, if you are in a competitive market, the least efficient unit is what sets the price. Typically, the least efficient unit is the one with the highest cost fuel, which would be a natural gas unit. And a natural gas unit, because it emits carbon, will see a higher price. The nuclear power plant will not see a higher price because its fuel does not entail any carbons. So, your costs as a nuclear plant operator, of which we are one, does not go up but the price you receive does go up.

Senator CARPER. All right. I want to ask you and Mr. Crane, I will start with Mr. Crane. In terms of the potential for offshore wind for generating electricity on the East Coast and maybe the

Mid-Atlantic, what kind of future do you see for that for our region of the country?

Mr. CRANE. Well, I think offshore wind has a very important future, because I think one of the things that we have had regional difference here is that basically offshore wind in the—I think it is called the Mid-Atlantic Bite, is basically the only large scale renewable resource that the Northeastern States have. And it is close to the load centers.

But right now the obstacles to getting offshore wind in the United States are pretty substantial. I mean, we do not have the infrastructure they have in Europe with, you know, purpose-build ships needs to be developed and other—you know, you need to have someone who takes the responsibility to build it. And you know, the building season is not that long in the Northeast United States.

So, I think there are obstacles, but I think there are several companies that are pursuing it, and I think it is an ideal area for a public-private partnership, and you know, Delaware, New York and New Jersey, I think, are all leaders in this area.

Mr. LAW. Senator, can I chime in on that one?

Senator CARPER. Please do, Mr. Law.

Mr. LAW. You might have missed my comments in the beginning——

Senator CARPER. I did.

Mr. LAW. LIPA and ConEdison, an investor-owned utility in New York City, and some other State entities are exploring what could be the country's largest offshore wind farm. It is about 13 miles off of the coast of the Rockaways, near Coney Island, to educate you geographically, Senator. And here is why we are looking at that.

One, we are looking at a private-public partnership to share the costs and share the power and share the risks. But unfortunately, all of the users were called load. And the load, in the New York City metropolitan area, is in New York City and on Long Island. We have got about 8 million people. All of our wind and hydropower is Upstate New York.

What we need to do, and what we will be doing, is comparing the cost of trying to import hydro and wind from Upstate New York, where it is plentiful, on congested transmission lines down to the load. Or might it actually be easier, more cost effective, to build it 13 miles off the coast, so you eliminate the aesthetic impact issues, and only have to do it 13 miles underneath the seabed to the substations on the Island.

So that is what we are looking at right now. Because at the end of the day, we think it is actually going to be cheaper to build a large scale offshore wind farm in the ocean than try to bring it down through the Adirondacks and the Catskills into where the population centers are.

Senator CARPER. OK. Good. Thanks very much.

Senator BOXER. Thank you so much, Senator.

Senator Cardin.

Senator CARDIN. Thank you, Madam Chair. And let me thank all of our witnesses on this panel.

Mr. Crane, I just want to underscore the point that you made and then refer to one of your facilities in Maryland, that climate change framework that will unleash the power of American capitalism and the innovative genius of American entrepreneurs. You promised that, given that framework, you can produce low carbon energy technologies.

Let me just point out one of your facilities that we are particularly proud of as far as the plans, and that is the facility located in the Vienna Steam Station, which is a 170-megawatt oil-fired generating station located along the Nanticoke River in Vienna, Maryland.

We understand that you are in the process of developing a new biomass and solar facility in Dorchester County, which will not only be good for the environment, will not only be good for what we are trying to accomplish on an energy policy in this country.

Dorchester, Maryland, has one of the highest unemployment rates in Maryland. And this, we look at it as creating jobs for the people on the Eastern Shore of Maryland. And I just really want to underscore—I think this project puts it all together for us, and I just really wanted you to know that we are watching what you are doing, and we are very proud of the plans that you have in regard to the Eastern Shore of Maryland.

Mr. CRANE. Well, Senator Cardin, I appreciate that. But I wish you had not said it in front of Mr. Izzo because he is sort of our competitor in the area. But you have told him all our secret plans.

[Laughter.]

Senator CARDIN. Mr. Izzo, I have a deal for you that you will not be able to refuse.

[Laughter.]

Mr. CRANE. But I think that, you know, our Vienna Plant is a 1970 zero oil-fired plant which rarely ever runs. But the great things about these old plants is they are perfect sites for redevelopment with renewables, and it really does not need to be either/or because they have the transmission system built around it. And the fact that we are looking at biomass and photovoltaic solar there, it is the type of thing that can be done in large parts of the country. It just takes a little bit of creativity.

Senator CARDIN. And we look forward to more creativity from the members of the panel.

Madam Chair, if I could, I want to reserve my last 2 and a half minutes to introduce the first witness of the next panel.

Senator BOXER. Well, Senator Merkley, you are it. And unless a Senator from the other side comes, we are going to move to the next panel.

Senator MERKLEY. Thank you, Madam Chair. I appreciate all of your testimony and particularly getting to the nitty gritty of the allocations which is something that we all immersed in as we try to figure out how to make this really work where the rubber hits the road.

Mr. Law, I appreciated your public power perspective, and the increase in the allocation for renewable energy and energy efficiency is something that we have worked hard on on this committee. And I appreciate your support to keep raising it.

Based on your comments on allowance allocations and increased investment in energy efficiency, I wonder if you could comment on the concept that we have considered at various moments, which is to require that utilities use a portion of their allowance specifically for energy efficiency.

Mr. LAW. I support that. And we support that. And again, it is way to, I guess, incentivize and encourage the utilities to help their customers to become more aggressive in the area of energy efficiency. So, we like that. I think, as I also pointed out, I am a public utility. LIPA is a public utility and is part of the APPA and the LPPC. I do not speak on behalf of all public utilities. But I am speaking on behalf of LIPA and the State of New York and what we support in New York.

Senator MERKLEY. Do you have any sense of how to strike the balance between addressing the additional costs to consumers versus investment in energy efficiency?

Mr. LAW. It is a challenge, especially when you come from a utility like mine where we have the second highest rates in the Nation already, not something that we are proud of, but something that is historical. Things that happened before I got there. But it is the challenge.

I think most customers, again regardless of their party affiliation or their political affiliation, I think they support efforts for renewable energy, energy efficiency. But when you ask them are you willing to pay more, you know, for that, that is when the tough part comes because people are hurting today because of the economic conditions.

And so it something that we need to be stronger in encouraging our investments in that because, as I think Senator Lautenberg said before, our system is working, it is reliable, it is working OK. But it could be a whole lot better. And we need to make some tough decisions to invest in our energy future if we are ever going to get to a clean energy economy.

Senator MERKLEY. Thank you. Mr. Johnson, I think you were making the case also to allow investment in renewable or clean energy investments. So, there are three possibilities of helping to address costs, investing in energy efficiency, which then reduce costs over the long term, and clean energy.

Would you expand a little bit on your advocacy on the clean energy side of the equation?

Mr. JOHNSON. Thanks very much, Senator. I think, in the perfect world, each State would be given broad flexibility to determine how they would distribute in rebates to ease consumer impact, in energy efficiency research and development, and in investments in other things. To me, some States are so far along the energy efficiency path that the low hanging fruit is gone, and they may want to target those dollars into a different arena.

In South Dakota, I would tell you, we would place a great value on energy efficiency. I mean to me, that is the first power source. And if you are not doing almost everything you can cost effectively for energy efficiency, then I think it is tough to talk about doing anything else.

But listen, some States are not set up to do that. And I would really ask that the U.S. Senate try to maintain maximum flexibility for States to design a system that will work best for their consumers.

Senator MERKLEY. I am going to give back the rest of my time because I know we are anxious to get on the next panel. I thank you all very much for you insights.

Senator BOXER. And Senator Merkley, I think one our problems that we have had with CBO is that, if we try to do what you want, which a lot of us do, and the utilities are split on it, it is terrible for our deficit problem. We have to take a haircut, put more money into deficit reduction. It makes no sense.

Senator MERKLEY. I am well aware. You might recall that I sat down with CBO on this very problem.

Senator BOXER. You called them. I know, it has been very difficult.

Senator WHITEHOUSE. Did you make any progress?

Senator MERKLEY. I can explain it to you in profound detail, but——

Senator WHITEHOUSE. It made no sense.

[Laughter.]

Senator BOXER. I do not know of anybody that has made any progress with it. They just do not seem to use any logic. Oh, do not tell them that I said, that, OK?

[Laughter.]

Senator BOXER. All right. Thinking out loud. Not good.

First of all, I know, Mr. Izzo, you never heard a word that Senator Cardin said about the plans for Maryland, right? Because I noticed that you were not really listening.

[Laughter.]

Senator BOXER. Let me just thank this panel. You have been terrific, every single one of you. And I just would leave us with an analogy that, as I look at the chart, and yes, it is going to cost consumers $5 a month, but by the way there are some even offsets to that for our lower income consumers. That is why AARP and Public Citizen and Consumer Union are very happy with the way we are moving on the bill. And we want to work with you. We want to keep working to make this a better product.

But you know, some of us are moms and dads, some of us are grandmas and grandpas as well, and some of us are uncles and aunts, and I think if we knew that our kids were in trouble and we had to get a better lock for the house, and it cost money, $50, plus you had to hire someone to put that lock in, maybe it was $100, it would be worth it. They would be safe.

And I think sometimes we get so involved in something that is not as large as what we are dealing with here. And we are seriously dealing with an issue that requires us all to pull together. We have got to come together.

And Mr. Hart is right. If the American people do not support us, it is not going to work. Just as in your situation, if your consumers do not understand it. And I have to tell you in our State, which is not perfect but it is close——

[Laughter.]

Senator BOXER. Our consumers are so driven with the notion that they can be part of the solution. And when Mr. Law explained, it is a lot about the rate, yes, but it is also about what you pay in the end. And in our State, we have realized this. So, our energy efficiency, and if Bernie Sanders I would explain, we are still Number One in that score. Because we get it. Our rates may be high, Mr. Johnson, but because we employ so much energy efficiency, the low hanging fruit that everyone can do, at the end of the day, they are doing OK.

Now, they can always do better. I wish they did not have to pay anything at all. But the bottom line here is, let us continue to talk, because I sense from everybody's comments that we all want the same thing.

So thank you very much and we will move on to the next panel. Thank you very much.

So, our next panel, Senator Cardin is going to introduce our first witness, so I will not. She is Shari Wilson, then we have Ronald Young, Peter Frumhoff, Larry Schweiger, Fawn Sharp, Jim Sims and our last witness was ill and could not be here, Dr. Green, and we wish him well.

Ladies and gentlemen, thank you very much for being here. We are going to start with our witness from Maryland. So, Senator Cardin, why do you not introduce her, and we thank that last panel. They were quite terrific. This has been quite a day for us all.

Senator CARDIN. Chairman Boxer, I know I speak for the Members of the Committee, thank you for the very informative hearing that has been put together today.

I am very proud to introduce Shari Wilson. Shari Wilson not only serves as Maryland's Secretary of the Environment, she is also Chair of the Maryland Commission on Climate Change. Governor O'Malley has made this a top priority of his administration. In that role, Secretary Wilson has been integral in creating and implementing our State Climate Action Plan, which outlines Maryland's adaptation efforts and goals.

Maryland has been one of the Nation's leaders in addressing climate change. Maryland is a member of the Regional Greenhouse Gas Initiative, the multi-State effort that is already benefiting from a cap and trade program. Maryland was one of those States that pressed for the so-called California Waiver in order to control greenhouse gas pollutions from the mobile sector.

And Maryland is one of the few States in America to actually produce a statewide plan to address climate change in a proactive way. And one of the main reasons that Maryland is in the forefront of these efforts is Shari Wilson.

We are fortunate to have her in Maryland, and we are very fortunate, I think, to have her help on this panel. I am pleased to welcome Shari Wilson to our committee.

Senator BOXER. Ms. Wilson, go right ahead.

STATEMENT OF SHARI T. WILSON, SECRETARY, MARYLAND DEPARTMENT OF THE ENVIRONMENT

Ms. WILSON. Thank you very much. Good afternoon, Chairman Boxer and members of the committee. It is a privilege to be here.

The past several weeks have been filled with optimism for public health and the environment in Maryland, with landmark legislation being introduced to restore the Chesapeake Bay and now hearings on the Clean Energy Jobs and American Power Act.

Senator Cardin, we appreciate your leadership in all of these efforts, and we are right there with you, of course.

Adaptation. This is word that is the shorthand for the changes we, as a society, need to make to be better prepared for the changes that we are and will continue to experience as a result of climate change. Whether it is making sure that our critical infrastructure—and expensive, I might add, infrastructure—for water, sewer and transportation is protected, or whether it is making sure new investments, a private home or a public road use design standards that will withstand the increased frequency of storms or floods or surges, we need to start making different decisions now to make sure we are targeting our investments smartly.

To date, efforts to adapt a climate change across our country lack cohesion. There are no clear roles, no clear responsibilities at the Federal, State or local level. We lack the necessary data and resources to comprehensively and efficiently prioritize our actions to adapt. We do, though, have the knowledge and tools and tremendous public health, economic and environmental motivations to better prepare.

The Clean Energy Jobs and American Power Act provides that needed structure, clarifying responsibilities, the framework for the data and assessments that need to be completed, and funding to get this work underway.

As is the case with greenhouse gas reductions, States have not waited for Federal action. To reduce greenhouse gas emissions, as Senator Cardin just mentioned, 10 States in the Regional Greenhouse Gas Initiative developed and are now successfully implementing a market-based regional cap and trade program to reduce emissions from the electricity generating sector. Likewise, to adapt to climate change, 30 States have adopted climate action plans. Four of those include adaptation strategies.

In 2007, Governor O'Malley ordered that we in Maryland prepare a climate action plan. Over 100 Marylanders, representing the private, the academic and the public sectors, came together to do so. And a key part of that plan is our adaptation strategy.

Adaptation plans are absolutely necessary for public health, economic and environmental reasons. Using Maryland as an example, we have over 3,000 miles of coastline, and over the past century we have experienced a foot of sea level rise, and projections show that we could experience another 2 to 3.4 feet of rise. We lose 580 acres a year to shoreline erosion; projections include projected losses of up to 161,000 acres lost of marshland.

These risks includes increased erosion along our streams, rivers and coastal shorelines, sediment being one of our major pollutants that we are dealing with the in the Chesapeake Bay, increased droughts and effects on water supply, groundwater tables, the likelihood of salt water entering our fresh water supplies and impacts on agricultural production, numerous economic consequences related to coastal property protection and the livelihoods that rely on clean water. And it includes threats to our historic resources, and once those are lost, we of course know they are lost forever.

The Clean Energy Jobs and American Power Act requires a national adaptation strategy. It requires Federal planning, and it requires State plans. It requires research to better develop our understanding of impacts to our water supply, our drinking and wastewater infrastructure, and it provides for mechanisms to mitigate impact on forestry and agriculture. It provides assessments funding, data collection and mapping funding to integrate the adaptation strategies nationally, at the State level, and at the local level.

All of these adaptation policies necessitate addressing a range of policies to make sure they protect vulnerable areas. It ranges from insurance to flood protection to health assessments and agricultural preservation. These raise local, State and Federal policy issues and a national framework to comprehensively shift our country to an effective adaptation strategy.

This bill that you are hearing today provides that clear national strategy. It involves coordinates plans, it is the only way to ensure effective prioritization of our expenditures to make sure we have regional coordination and to set data and assessment priorities for the country.

It also provides much needed dedicated funding to get this work underway as soon as possible. In particular——

Senator BOXER. I am going to ask you to sum up. OK?

Ms. WILSON. Yes, thank you. The coastal and Great Lakes adaptation program acknowledges and prioritizes the unique challenges that are faced by coastal States. This is a critical part of the adaptation strategy and we applaud the inclusion of the provisions in this bill.

Thank you for your consideration of Maryland's viewpoints today, and we look forward to working with you on any questions you may have.

Thank you.

[The prepared statement of Ms. Wilson follows:]

Testimony of Shari T. Wilson, Secretary
Maryland Department of the Environment

Before

The Senate Committee on Environment and Public Works

The Clean Energy Jobs and American Power Act (S. 1733)

Wednesday, October 28, 2009

Chairman Boxer, Ranking Member Inhofe and honorable members of the Committee, thank you for the opportunity to share Maryland's perspective on the need for climate change adaptation and the critical importance of developing a national adaptation strategy.

Adaptation describes how we prepare for the impacts of climate change and how we mitigate the impacts we are experiencing, and will continue to experience. To date, efforts to adapt for climate change across our Country lack cohesion. There are no clear roles, and no clear responsibilities at the federal, state or local level. We lack the necessary data and resources to comprehensively and efficiently prioritize adaptation activities. At the same time, as states are demonstrating, we certainly have the knowledge, the tools and tremendous public health, economic and environment benefits to gain by adapting and mitigating the effects of climate change. The Clean Energy Jobs and American Power Act, at last, provides the path forward. This legislation defines the needed structure – clarification of responsibilities, the framework for necessary planning and action, and the outline for collection of data and funding – to get this important work underway in a smart, efficient and effective way.

As is the case with greenhouse gas emission reductions, States have not waited for federal action. To reduce greenhouse gas emissions, the ten States in the Regional Greenhouse Gas Initiative moved forward to develop, and are now successfully operating, a market based regional cap and trade program to reduce emissions from the electricity generating sector. Likewise, to adapt to climate change, many States have moved forward to develop plans and strategies to adapt to climate change and are now implementing those plans. Maryland's own Climate Action Plan, initiated by an Executive Order issued by Governor O'Malley, details Maryland's need for adaptation strategies, prioritization of data collection, assessments and implementation, much like the provisions of Subtitle C of this Act.

Impacts of Climate Change in Maryland

Climate Change is already impacting Maryland. With over 3,000 miles of coastline, more than California, we have already experienced one foot of sea level rise. Increasing sea levels have the potential to cause profound changes in Maryland's environment, natural resources and economy. The magnitude of the impact will depend not only on our ability to reduce future global carbon dioxide emissions, but on our ability to successfully implement adaptation strategies at the federal, state and local levels. A national adaptation strategy and significant federal funding for coordinated state and federal adaptation programs are critical to mitigating the effects of climate change.

The impact of climate change in Maryland will manifest itself in many different ways. Rising temperatures, changes in precipitation patterns and more frequent and severe storms will affect the State's water resources, our agriculture and forestry sectors, our aquatic and terrestrial ecosystems, our land use, our infrastructure and the health of our citizens.

As a coastal state with one of the world's largest and most complex estuarine systems, rising sea levels and increased storm severity present Maryland with a unique set of challenges. Our 3,000 miles of shoreline equates to many vulnerable low-lying coastal areas. The Chesapeake Bay area is ranked as the third most vulnerable region in the nation to the impact of sea level rise. In addition to the sea level rise of one foot already experienced, Maryland projects that during this century, sea levels could rise an additional 2.7 to 3.4 feet, submerging existing tidal marshes and inundating low-lying areas. Rising sea levels will increase Maryland's vulnerability to storm events, shoreline erosion and salt water intrusion into our groundwater aquifers.

Maryland has thousands of miles of developed waterfront property along its coast, including many historic settlements such as Smith Island. The State's coastal areas and barrier islands contain billions of dollars worth of public and private investments that are threatened by rising sea levels and increased storm surge. Currently our state is losing approximately 580 acres per year to shoreline erosion. Thirteen Chesapeake Bay islands once mapped on nautical charts have already disappeared beneath the water's surface. In a 2008 report, the National Wildlife Federation estimated that approximately 400,000 acres of land on the Chesapeake's Eastern Shore could gradually be submerged. The Federation projects that by the end of the century, the Bay region will lose more than 161,000 acres of brackish marsh, 69% of its estuarine beaches, 58% of its ocean beaches and more than 50% of its tidal marshes. The loss of tidal wetlands and marshes will mean loss of critical habitat for many species of birds, fish and plants and a decline in the populations that are dependent on them.

As Maryland and the other Bay states implement aggressive measures to accelerate restoration of the Bay, we are concerned that rising sea levels and changes in precipitation patterns will impede our efforts to restore water quality. For example, reversing the loss of underwater grasses is critical to the Bay restoration effort. Rising sea levels and increased shoreline erosion will adversely impact submerged aquatic vegetation through reduced light penetration as a result of increased water depth and suspended sediments. An increase in total precipitation and storm intensity could lead to increased stream flows, more sediment erosion, turbidity and nutrient pollution with corresponding adverse impacts on aquatic vegetation and marine life. The Chesapeake Bay Program's Scientific and Technical Advisory Committee report, *Climate Change and the Chesapeake Bay* and the Executive Order 13508, Draft Section 202(d) Report, *Chesapeake Bay Watershed Climate Change Impact,* both address the impacts of climate change on the Bay and collectively recommend the need for action on adaptation planning at the regional, state and national level.

Rising sea levels, storm surges, increased frequency and intensity of storm events and drought conditions all have the potential to significantly impact our drinking water supply and our drinking and wastewater infrastructure. This legislation specifically acknowledges this risk and addresses the impact on infrastructure.

In the State's metropolitan areas, surface water is the primary source of drinking water. An increase in the frequency and intensity of storms can degrade surface water quality by causing additional sediment erosion and runoff, which increases turbidity levels and makes the raw water more difficult to treat using conventional methods. In addition, the higher levels of sediment can reduce the effectiveness of water treatment filters in removing microbial pathogens.

More intense storms are likely to compromise the efficacy of wastewater treatment technology and they can cause more sewer overflows in municipal systems with combined sewer/stormwater systems, resulting in increased discharges of untreated sewage into surface waters. Combined sewer overflows degrade water quality and threaten downstream drinking water systems.

On Maryland's Eastern Shore and in the rural coastal areas of the State where groundwater is the primary source of drinking water, rising sea levels can increase the rate of saltwater intrusion into underground aquifers, jeopardizing the suitability of the aquifers for drinking water. There is evidence that salt water intrusion is already occurring on the Eastern Shore. Rising sea levels and more severe storm surges could infiltrate septic systems and drainage fields located in coastal low-lying areas, causing further contamination of groundwater aquifers. More frequent and longer lasting droughts could reduce water levels in the State's reservoirs, necessitating more frequent water use restrictions. These impacts will further challenge the State in our current efforts to develop a long-term strategy to manage our water resources for future generations. The *Clean Energy Jobs and American Power Act* not only provides funding for research to develop a better understanding of how climate change will impact our water supply resources and infrastructure and how we can protect these essential resources, but also reserves funding for projects to adapt our drinking and wastewater infrastructure to the effects of climate change. Similarly, it is just plain common sense to implement the "Watersense" program outlined by this Act. It is incumbent upon us all to promote water conservation to the greatest extent possible. Even in a State like Maryland, where traditionally water supply has been abundant, the recent decade has brought droughts and a clear need for better data and assessment of groundwater supplies. If this is a need in Maryland, we can be assured that it is a much more dire need in other parts of the Country.

As regional warming increases, ecosystems and species that require lower temperatures and specific forest systems will face shrinking habitat, and if unable to migrate, possible local extinction. Some forest types such as hemlock, mountain ash, sugar maple, and butternut could disappear from the State altogether. Increasing temperatures may have significant effects on the ability of plant species to regenerate as the result of a shift in the timing of budding, flowering and pollination. Climate change is expected to result in an increase in non-native and invasive species.

Rising air and water temperatures will adversely impact plant and animal species that are sensitive to subtle changes in temperature. For example, an increase in Bay water temperature could reduce populations of striped bass and other cooler water species.

The projected increase in the number of short, medium and long-term droughts in the Northeast will affect our forestry and agricultural sectors. Prolonged droughts could significantly impact our ground and surface drinking water supplies.

These kinds of impacts, and many others, are likely to be experienced to differing degrees by all states. The *Clean Energy, Jobs and American Power Act* specifically addresses the impact of sea level rise on agriculture and forestry, providing much needed mechanisms to mitigate the impacts on these resources and enable us, as a country, to better prepare for those impacts.

Maryland's Adaptation Plan

Maryland's Climate Action Plan, a comprehensive strategy for reducing State-wide greenhouse gas emissions and adapting to its consequences, recommends 18 specific adaptation legislative, policy, and planning actions to reduce the impact to existing built environments and future growth and development, protect human health, safety and welfare and protect and restore the State's forests, wetlands and beaches. The recommended strategies focus on assessing and protecting existing vulnerable infrastructure, assessing the need for changes to the State's building codes to protect future development and incorporating adaptation strategies into state and local government land use and other comprehensive planning programs. Likewise, this proposed Act specifically addresses the need to update and improve building codes, provide for the necessary assessment, data collection and mapping to integrate climate change adaptation into a range of state and local planning and programming.

Implementation of the State's adaptation strategy is well underway. In 2008, Maryland passed two pieces of key legislation called for in the strategy: The Living Shoreline Protection Act and amendments to the Chesapeake and Coastal Bays Critical Area Act. Living shorelines, or soft shorelines, are a smarter way to protect shoreline from erosion in the face of increased flooding and sea level rise while providing greater habitat benefits. In fact, living shoreline projects are underway throughout Maryland's portion of the Bay. Maryland's critical area law provides additional protections for conservation and development in areas within 1,000 feet of Maryland's shoreline. Both initiatives will reduce Maryland's vulnerability over time and protect natural resources from the impacts of sea level rise by restoring natural shoreline buffers such as grasses and wetlands and limiting new growth in vulnerable areas.

Effective adaptation necessitates a careful review of policies to ensure they are consistent with protecting vulnerable areas. For example, Maryland's Climate Action Plan addresses insurance, flood protection, health assessment needs and agricultural preservation issues. These aspects of adaptation raise local, state and federal policy issues and a federal framework is needed to comprehensively shift to an effective adaptation strategy. The legislation addresses this need, for example, through its requirement for development of a National Strategic Action Plan to address the impacts of climate change on public health, and through its provisions requiring the federal adaptation plan to establish programs to address flooding impacts.

More recently, Maryland's Climate Change Commission has initiated development of a second phase of adaptation planning focused on addressing the impacts of increasing temperature, changes in precipitation patterns and increased storm frequency and intensity on our water resources, agriculture and forestry sectors, aquatic and terrestrial ecosystems, human health, transportation systems and land use. Our goal is to produce adaptation strategies for each of these sectors by June 2010. These actions would be far more efficient and effective if coordinated with a national strategy as called for in the proposed legislation.

The Import of a National Strategy

States and local governments are at the front lines of planning for climate change. These efforts though are in significant need of action at the national level.

First, effective adaptation needs a clear national strategy. This strategy should integrate a national approach to natural resource adaptation based on effective coordination among state and federal agencies. In the Chesapeake Bay region alone, at least three separate climate change adaptation strategies have been produced in the last year and half – all by different governmental organizations and all calling for enhanced intergovernmental coordination. Maryland supports the provisions of the bill that establish a Natural Resources Climate Change Adaptation Panel, provide for development of a national adaptation strategy in close collaboration with the states and require that strategy to include specific mechanisms for ensuring coordination and communication between the federal and state natural resource agencies. Prioritizing actions is the most efficient way to begin to address the wide ranging impacts of climate change and is also fundamental in Maryland's Climate Action Plan implementation process.

Second, if the Country is to successfully address adaptation, dedicated funding is necessary for effective state adaptation plans. In addition to funding provided through the Natural Resources Climate Change Adaptation Account, funding specifically targeted to protection of the Chesapeake Bay and other estuarine systems through the Coastal and Great Lakes Adaptation Program acknowledges the need to address rising sea levels, accelerated shoreline erosion, salt water intrusion and other impacts that are unique to the coastal states.

Finally, the key role of states in climate change adaptation planning, including the valuable research contribution of state academic institutions, must be clearly established and supported by federal programs. We support provisions of this legislation that recognize the importance of a strong state/federal partnership in the development of climate change science reflected in requirements for the establishment of the National Climate Change and Wildlife Science Center to work in collaboration with state agencies and the representation of state interests on the national Science Advisory Board to be established by the Departments of Commerce and Interior. Provisions of the bill establishing the National Wildlife Habitat and Corridors Information Program are designed to facilitate collaborative efforts to develop a GIS database of fish and wildlife habitat corridors and mechanisms to support joint federal/state research, mapping and planning.

In conclusion, a collaborative relationship between the federal and state government agencies with responsibility for developing and implementing a national adaptation strategy is essential if we as a nation are to be successful in understanding and adapting to climate change. The *Clean Energy Jobs and American Power Act* establishes the foundation for a strong federal/state partnership and the development of a cohesive national adaptation strategy.

Thank you very much for your consideration of Maryland's testimony today.

Environment and Public Works Committee Hearing
The Clean Energy Jobs and American Power Act (S. 1733)

Responses of Shari T. Wilson to Follow-Up Written Questions
October 29, 2009

Questions from:

Senator Bernard Sanders

1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Response to Question: Yes. Significant investments in energy efficiency, renewable energy and other clean energy programs are a key component of a successful national climate change program. The *Clean Energy and Jobs and American Power Act* should ensure that local electricity distribution companies invest at least 50% of the value of allowances they receive in such programs. In addition to reducing GHG emissions, these investments will also result in a direct financial benefit to consumers through reductions in electricity demand.

Senator James M. Inhofe

1. I share your concern with meeting drinking water and waste water needs for your population in the future. In my home state of Oklahoma we have undergone a comprehensive water plan to ensure we can meet Oklahoma's water needs for the next 50 years. I understand that more states are beginning this process. Has Maryland considered this approach to water planning?

Response to Question: Yes, Maryland has a comprehensive approach to water planning. A 2005 Executive Order charged an Advisory Committee on the Management and Protection of the State's Water Resources with assessing the condition of the State's water resources management program, recommending steps to assure that the program will provide for the long-term use and protection of Maryland's water resources, and recommending a strategy and appropriate funding for sustainable management of these resources. While the Advisory Committee recommended a more robust, comprehensive, fully-integrated State water resources management program, the next step is the development of two necessary water supply studies: the Coastal Plain Aquifer Study and the Fractured Rock Water Supply Study to better define water resources and begin to obtain the data that will be necessary to plan in the face of increased drought frequency.

While this country, through the Safe Drinking Water Act and the State Revolving Loan Fund has developed a very safe system of water supply, less funding has been available for assessing groundwater supplies. This type of assessment work will be critical to prudently plan for the increasing variability of precipitation patterns. S. Bill 1771 would specifically provide resources dedicated to that purpose and initiate this critical work.

The planning provisions of the Bill would also significantly enhance the opportunity for close regional collaboration. As we all recognize, natural systems such as groundwater systems do not recognize political boundaries. Together, the funding and planning provisions of the proposed legislation significantly improve the country's ability to be prepared for climate change.

2. I believe that our problems with water planning are not simply tied to climate change but also aging infrastructure and lack of resource planning. I have long been a supporter of infrastructure bills such as S. 1005 the Water Infrastructure Financing Act of2009, which I co-sponsored with Senators Boxer, Cardin and Crapo. A robust SRF would address many of your concerns. If the SRF bill is passed and more funds are made available to meet state and local needs, would it alleviate many of the concerns you have expressed? You mention the need for a coordinated research strategy on water adaptation. What are the improvements needed for existing research? Are you concerned that an increased Federal role in climate adaptation could undermine efforts that Maryland has put in place, understanding that Maryland is closest to the problems that Maryland has when dealing with climate adaptation?

Response to Question: Yes, I agree that our problems with water planning are not simply tied to climate change, but also aging infrastructure and lack of resource planning. Maryland just completed its most recent drinking water and wastewater needs survey, with the State's needs totaling $14 billion. Nationally, the difference between current investment and need over the next 20 years is $534 billion. So it is obvious from these numbers that the nation has major needs independent of climate change. Maryland is a strong advocate for a more robust SRF to help address this funding shortfall and would welcome the additional funding contained in S. 1005—The Water Infrastructure Financing Act of 2009.

However, it should be noted that the infrastructure funding necessary for the states to adapt to climate change is a separate issue and need from aging infrastructure. The most recent national water and wastewater needs survey does not include funding needed for climate change adaptation. This is why it is essential that the "Clean Energy Jobs and American Power Act" include funding for water and wastewater adaptation, as is currently included in Section 381 - Water System Mitigation and Adaptation Partnerships. Federal funding for these adaptation projects will provide a much needed source of funding to facilitate these projects and will help to defray costs that would otherwise be passed along in the form new water and sewer assessment fees to ratepayers.

We advocate for the expansion of existing research on water adaptation. Under Subtitle B Section 211, the "Clean Energy Jobs and American Power Act" provides funding for a comprehensive study into the full range of impacts on drinking water utilities, including impacts on water supplies, facilities, and customers. This comprehensive study is essential to develop effective federal and state water adaptation plans and assist the utilities in adapting to the effects of climate change.

I am not concerned that an increased Federal role in climate adaptation could undermine efforts that Maryland has put in place. We need the National Strategy that this legislation provides. Climate adaptation has to be a partnership between the federal government, the States, and local governments. The federal government can provide much needed funding and specific expertise for climate adaptation that States and local governments do not have. Also, the federal government is best positioned to coordinate adaptation

A prime example of this is the Chesapeake Bay, with its 64,000 square miles of watershed that lie in six states and the District of Columbia. Climate change will present an entirely new set of challenges for the Bay states in our efforts to restore the Bay's water quality. The federal government can help by coordinating adaptation efforts for the Bay and providing additional funding to the Bay States.

While Maryland is closest to Maryland's climate change problems, and will in many instances, be implementing the adaptation strategies to minimize the effects of climate change, the assistance of the federal government is essential to climate change adaptation efforts.

3. What can the bill do to ensure that your programs are protected, while maintaining a proper federal/state partnership?

Response to Question: With the exception of the preemption of state trading programs during the first six years of the federal trading program, the bill largely preserves existing and future state regulatory authority, and in at least one instance, actually expands state authority. We were very pleased to see the many provisions in the bill that provide for state representation on federal climate change panels and require EPA and other federal agencies with responsibility for climate change programs to work collaboratively and in close cooperation with the states to develop and implement a national climate change program. The bill recognizes the leadership role that the states continue to play in addressing climate change and the manner in which federal agencies can benefit from the expertise developed by the states. These provisions should be retained in the Senate bill and in the climate change bill ultimately passed by Congress.

4. What steps is Maryland taking to help farmers adapt to climate change?

Response to Question: Protection and conservation of the State's agricultural land is an important strategy in Maryland's Climate Action Plan. Maryland has as its goal, the protection of 1.2 million acres of productive agricultural land by 2020. The goal is to ensure no net loss of agricultural land.

Development of an intra- and interstate nutrient and carbon trading program for farmers in Maryland and the other Bay states is another important strategy in Maryland's Climate Action Plan. Such a trading program will allow Maryland farmers to benefit economically from implementation of Best Management Practices that go beyond regulatory requirements and reduce the use of nitrogen fertilizers, which release nitrous oxide, a potent greenhouse gas.

Climate change impacts to our water supply resources as a result of drought and salt water intrusion in the coastal areas of the State have the potential to significantly impact the availability of water for agricultural irrigation needs. Maryland is currently considering changes to its water re-use policy in an effort to facilitate more widespread use of gray water for a broader range of uses, including irrigation needs.

The Maryland Climate Change Commission has recently implemented Phase II of developing an adaptation strategy to focus more attention on agricultural and other sector based impacts. A principal focus of this second phase is assessment of the impacts of temperature, drought, changes in precipitation patterns and increased storm severity on six specific sectors, including agriculture.

5. If this bill became law, could the mandate to employ "all practical means" to protect

fish and wildlife be used in litigation to undermine federal and state laws, agreements and contracts governing the allocation of water resources and the use of public lands?

Response to Question: It is difficult to speculate about how attorneys might use specific phrases in litigation. This provision of the Bill would, though, ensure the employment of adaptation strategies to undertake effective climate change mitigation measures.

6. Do you believe the mandate to employ "all practical means" to protect fish and W'ildlife could be used to justify involuntary re-allocations of water, land and other resources away from current users in order to protect fish and wildlife?

Response to Question: It would seem that if alternative water supplies were available to current users, in certain circumstances it might be practical to reallocate and substitute alternate water supply.

7. Should the bill put safeguards for domestic agriculture on an equal footing with safeguards for fish and wildlife?

Response to Question: A principal focus of the adaptation provisions of the bill is on mitigation of climate change impacts that have the potential to affect the agriculture sector of our economy. National and state natural resources adaptation plans will address, among other things, impacts to our water supply from more frequent and longer lasting droughts, salt water intrusion into our fresh water aquifers, changes in patterns of precipitation, rising temperatures and sea levels and shifts in vector populations—impacts that all have the potential to diminish or otherwise affect agricultural production in this Country. Agriculture will benefit directly and significantly from implementation of federal and state adaptation plans that address and mitigate these impacts.

Senator Lamar Alexander

1. A company called PurGen is trying to build a coal-gasification-and-carbon-sequestration plant in Linden, New Jersey. The plant would trap its carbon emissions and sequester it in ocean rock formations off Atlantic City. Secretary of Energy Steven Chu has said carbon sequestration will be an essential strategy in coping with climate change. So who is opposing the PurGen plant? The Sierra Club, the Edison Wetlands Association, the New Jersey Environmental Federation. "This plant is a $5 billion environmental ponzi scheme that not only won't work but will lead to environmental disaster," they say. Several environmental groups in New England (Vermonters with Vision, People's Task Force on Wind Power, Ridge Protectors, Save Vermont Ridgelines, Green Berkshires, War Against Wind) have worked to oppose wind projects in northern New England. These and other opposition groups have managed to stall wind farms in more than a dozen states across the country.

a. How can we expect to pass a bill that is saying take carbon emitting plants offline or phase them out or implement carbon capture technology or put up clean power like wind, when projects like this are being blocked by environmental concerns across the country?

Response to Question: The siting of new large facilities of any type will generate concerns. To effectively answer questions and reduce controversy a range of options exist. Through environmental assessments, investment in research, improving technologies and education about these new technologies, siting concerns, environmental impacts and concerns about emerging technologies associated with development of new clean energy sources can be reduced. These same concerns exist with today's well tested technologies and are always a challenge. A well planned project, including a candid and effective outreach component, can be very effective in alleviating concerns.

2. As Senator Boxer has stated, the analysis of these cap and trade bills says that 100 nuclear plants or more, in addition to what we have today, will need to be constructed to meet the carbon reduction goals.

a. How can these reactors be built if they are meeting the same opposition from environmental groups?

b. Is it really plausible to say these plants will be built because of Kerry-Boxer or Waxman-Markey when there will be attempts to block and litigate by environmental groups?

Response to Question: Construction of new nuclear power plants and units in this Country is subject to a comprehensive and well-established licensing process that provides for public participation. As we mentioned in the answer to the preceding question, the siting of new large facilities of any type will generate concerns. A well planned project, including a candid and effective outreach component, can be very effective in alleviating concerns.

While we respectfully decline to speculate on the ultimate outcome of pending or future licensing proceedings, *the Clean Energy and Jobs and American Power Act* provides a forward looking plan for the Country to enhance energy independence. This will lead to development of new regulations, new nuclear power proposals and new technologies. Through such a transformation, once can expect some litigation, but the possibility of litigation should not deter us from this opportunity for energy independence.

Senator BOXER. Thank you so much.

Our next panelist is Ronald E. Young, President of the California Association of Sanitation Agencies. And we are very happy to have you here, sir.

STATEMENT OF RONALD E. YOUNG, PRESIDENT, CALIFORNIA ASSOCIATION OF SANITATION AGENCIES

Mr. YOUNG. Thank you, Madam Chair.

Today, I represent my local agency, which is a water and wastewater agency that recycles water for about 100,000 people. I represent the California Association of Sanitation Agencies, which includes 124 publicly owned treatment works that treat wastewater for over 25 million people in California.

And I also have the honor of representing the National Association of Clean Water Agencies, NACWA. They represent over 300 POTWs nationwide which serve over 80 percent of the sewered communities in this Nation.

I am grateful to appear, and I am pleased that this bill, S. 1733, represents a solid step toward finding solutions for water sector climate change impacts. And we support this endeavor.

The POTW owners and operators believe we can play an important role in participating in climate change solutions. We generate sources of renewable energy, such as digester gas, biosolids, and biodiesel. If harnessed, these resources can reduce greenhouse emissions. And we also produce recycled water, and this is a climate resilient water supply.

Water supply and water quality services are like the canary in the coal mine. POTWs will be among the first and hardest hit by climate change. This is because most communities use gravity as their source of energy to convey wastewater to the treatment plants. These treatment plants are located at the lowest end in the watershed. In coastal areas, the plants are often located along the coast or in tidal estuaries.

Even in the case of inland locations, these outfalls and plants are located in river valleys and flood plains. Therefore, our agencies acutely experience the effects of either sea level rise or storm surge events attributable to climate change.

In the West, and particularly in California, my State, we are also experiencing a severe drought, and it has wreaked economic havoc on the entire State. The impact of unpredictable precipitation and decreased water content in the snow pack has resulted in a statewide effort to reduce water consumption. This reduction is being done through conservation. It is also forcing consideration of construction of alternative water supply production such as recycling and desalination plants.

Climate analyses indicate that modified weather patterns, depending on the region, will produce too much or too little water. For example, severe storms that can lead to surges of wastewater flows that can overwhelm collection systems and treatment plants. Alternatively, drought conditions lead to reduced flows and increased concentration of pollutants that compromise wastewater flows.

Other impacts that we believe our agencies expect to encounter include rising sea levels that inundate infrastructure and cause health risks, warmer ambient surface water temperatures that will likely lead to new regulatory requirements and associated treatment needs, and decreased potable water supplies requiring greater reuse and recycling of wastewater effluent.

Today, I am proud to present this report that NACWA and the Association of Metropolitan Agencies are releasing. It is a study on the impacts and challenges the wastewater community expects to encounter. It is entitled Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs.

I provide a copy of the study and request that it be included into the record as part of the formal committee record.

Senator BOXER. That will be done.

Mr. YOUNG. Thank you.

The most important finding in this report is that climate change impacts on agencies will impose costs as high as $900 billion by the year 2050, depending on how quickly we reduce emissions in the meantime. This is in addition to the existing half a trillion dollar funding gap for water infrastructure. That is a total of almost $1.5 trillion.

The report found agencies would need to address the issues of bigger rainstorms, higher treatment requirements, more energy demands, more shutdowns of service because of these calamities, more emergency situations, and less safe and reliable water supplies.

There are opportunities, though, and these come with the energy that can be produced from our wastewater solids. We believe that up to 10 times as much energy can be produced from the solids out of wastewater as is required to treat our wastewater.

So, one of the things that is very important for this legislation is, and we request, that the committee explicitly identify biogas and biosolids as renewable energy sources for purposes of meeting the goals and objectives of this bill.

In conclusion, CASA and NACWA support the comprehensive climate change legislation, and we believe the bill will put us on the path toward reversing and avoiding catastrophic impacts of climate change.

I look forward to answering your questions.

[The referenced report was not received at time of print.]

[The prepared statement of Mr. Young follows:]

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TESTIMONY

ON THE

CLEAN ENERGY JOBS AND AMERICAN POWER ACT

S. 1733

PRESENTED BY

RONALD E. YOUNG

GENERAL MANAGER

ELSINORE VALLEY MUNICIPAL WATER AGENCEY

ON BEHALF OF

CALIFORNIA ASSOCIATION OF SANITATION AGENCIES

AND

NATIONAL ASSOCIATION OF CLEAN WATER AGENCIES

SUBMITTED TO THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

U.S. SENATE

OCTOBER 28, 2009

Ensuring Clean Water for California

Thank you Chairman Boxer and members of the Committee. I am Ronald E. Young, General Manager of Elsinore Valley Municipal Water District located in Lake Elsinore, California. I appear before the committee today as President of the California Association of Sanitation Agencies (CASA), a statewide organization representing 124 publicly owned wastewater treatment works (POTWs) that provide water quality services to more than 25 million Californians. Aside from my agency, CASA represents small, medium and large agencies representing over 90% of California's sewered population. I also appear before you on behalf of our national organization, the National Association of Clean Water Agencies (NACWA) that represents nearly 300 POTWs across the country including numerous California wastewater agencies. Collectively, NACWA members provide wastewater treatment services to 80% of all sewered communities.

At the outset, we are grateful for the opportunity to appear before the Committee and to lend our support to the Committee's efforts to address climate change impacts. The Clean Energy Jobs and American Power Act (S. 1733), sponsored by Chairman Boxer and Senator John Kerry, represents a significant step in this endeavor. Equally important, S. 1733 will position our nation to leverage economic opportunities that will evolve from the new energy efficient economy.

POTW owners and operators believe we can play an important role in participating in climate change solutions. We generate sources of renewable energy such as digester gas, biosolids, and biodiesel fuel that if harnessed can reduce energy consumption and reduce greenhouse gas emissions. We also produce recycled water - a climate resilient water supply.

CASA and NACWA believe that water supply and water quality are like the canary in the coalmine. Our member agencies will experience the first significant infrastructure impacts of climate change. POTWs will be among the hardest hit by climate change. Because most communities use gravity to convey wastewater to treatment plants, wastewater plants are generally located at the low point in each watershed. In coastal areas, plants are often located along the coast or within an estuary. Even in the case of inland locations, plants and the outfalls are within river valleys and floodplains. Therefore, wastewater agencies will acutely experience the effects of either sea level rise or storm surge events attributable to climate change.

Wastewater collection systems are already stressed when managing wet weather flows. Under climate change conditions, we expect an increase in extreme storm events - indeed, recent weather events in places like Atlanta and Louisville appear to be a portent of the new climate-modified environment we face. These extreme storms can exceed the current capacity of much of our wastewater infrastructure, meaning we will need to invest significantly in upgrading systems to prevent raw sewage overflows from endangering public health.

In the West, and particularly in my state of California, we are experiencing severe drought that has wreaked economic havoc in the Central Valley, the nation's most productive agricultural region, due to greatly reduced water supplies. Throughout California, the impact of unpredictable precipitation and decreased water content in snowpack has resulted in a statewide effort to reduce water consumption. This is being done through conservation efforts and the consideration of construction of alternative water supply production such as recycling and desalination projects.

Across the nation, climate analyses illustrate that there will be modified weather patterns that, depending on the region, will produce too much or too little water. In each instance, this will impose substantial operational costs upon public agencies. For example, severe storm events can lead to surges of wastewater flows that can overwhelm collection systems and treatment plants. Alternatively, drought conditions can lead to reduced flows and increased concentration of pollutants that comprise the wastewater flows. In each case, these events will likely require changes in treatment system operations and control technologies. Other impacts that we believe our agencies are expected to encounter include: rising sea levels that inundate infrastructure leading to increased health risks, warmer ambient surface water temperatures which will likely lead to new regulatory requirements and associated treatment needs, and decreased potable supplies which will require greater reuse and recycling of wastewater effluent.

These are new and real challenges that public officials must address in addition to the mounting demands on our limited resources for traditional infrastructure needs.

THE NEED FOR ADAPTATION ASSISTANCE

Today, NACWA and the Association of Metropolitan Water Agencies (AMWA) have released a study on the kinds of impacts and challenges the wastewater community expect to encounter, and the projected costs of meeting those challenges. Titled "Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs", the report examines the likely climate-related effects to our water resources and the resulting impacts to our water systems. I provide a copy this study and request that it be included as part of the formal committee record along with my testimony. I will highlight the findings below.

As CASA and NACWA have testified in the past, current infrastructure demands that our agencies must meet already are estimated to exceed half a trillion dollars. This amount does not take into account the costs to address challenges of climate change. According to the NACWA/AMWA report, we expect the costs for water and wastewater agencies to adapt to climate change to be in the range of one-half to one trillion dollars just thru 2050, as explained in greater detail below.

We also believe that climate change presents us with opportunities. It is forcing our agencies to find ways to build upon the innovative energy savings developed over the past few decades. According to Water Environment Research Foundation, POTWs could generate ten times the amount of energy required to actually treat wastewater flows. In fact, these public agencies have the potential of producing up to twelve percent of nation's energy demand. The development of this important legislation should incorporate this underutilized energy resource as part of the solution to reduce greenhouse gas emissions and advance energy security. We therefore request that the committee explicitly identify biogas and biosolids as renewable energy resources for purposes of meeting the goals and objectives of S. 1733.

With these general points of interest, I would like to turn to specific provisions contained in S. 1733 that we believe offer real promise to reduce the impacts of climate change upon our agencies and move the nation toward a sustainable energy policy.

We are pleased that S. 1733 recognizes the unique challenges that climate change will pose to our nation's water, wastewater and stormwater utilities and includes provisions to help address those challenges. Specifically, S. 1733 includes the "*Water System Mitigation and Adaptation Partnerships*" (Section 381) program which would establish a competitive grants program to assist water systems with adaptation needs. The nation's water, wastewater, and stormwater utilities would be able to be eligible to compete for funding to undertake projects to adapt their operations to climate change impacts. Eligible projects include efforts to conserve water or increase the efficiency in its use, preserve or improve water quality, rebuild or relocate threatened infrastructure, protect source waters and ecosystems, or implement advanced treatment technologies such as water reuse, recycling, and desalination.

According to our early analysis, wastewater utilities across the U.S. can expect:

- Increased extreme precipitation events,

- Increased treatment requirements,
- Higher energy demand,
- Increased service disruptions from flood,
- Increased emergency response and recovery, and
- Declining safe and reliable water supplies.

Some of the adaptation strategies that wastewater facilities will likely use to address these challenges include:

- Increasing the use of both green and grey infrastructure and processes to manage wet weather flows, as well as more efficient treatment technologies. Though we anticipate green infrastructure technologies can help us manage larger volumes of stormwater to some degree, these approaches alone are insufficient. As witnessed by the recent flooding in Georgia, wastewater plants can quickly become overwhelmed and discharge partially treated or raw sewage due to extreme storm events unless there is sufficient capacity to handle the extra volume.

- Increasing the treatment of effluent, including cooling of the effluent, to address likely increased surface water temperatures of receiving bodies whose ecological health will be compromised under global warming.

- Relying more heavily on the use of recycling and reuse technologies so that wastewater can help compensate for the decrease in drinking water availability and supplies. In California, we have seen a dramatic increase in the interest to develop such projects to respond to the drought and ensure a safe and reliable water supply.

- Elevating pumping stations, building levees and, in some circumstances, relocating treatment works to avoid rising sea levels from rendering the wastewater plant inoperable.

These are just a few of the impacts and adaptation strategies considered by the report. This study, conducted by the consulting firm CH2M Hill, is an early assessment of the adaptation costs. It does not account for all likely impacts or future regulatory controls that policy makers may deem necessary. However, it does provide us with an understanding of the magnitude of the problems we in the wastewater sector face and the estimated price tag could be as high as $1 trillion unless substantial reductions of GHG occur.

Even if our agencies and others initiate climate change mitigation programs and projects , existing federal programs fail to account for the fact that current atmospheric concentrations of greenhouse gases (GHG) ensures that our climate will undergo some degree of warming which will lead to severe impacts on our water resources and their treatment. CASA and NACWA firmly believe that if wastewater treatment facilities are to provide uninterrupted, high-quality service to their customers and install new technologies and processes to meet climate change challenges, any climate change bill must address these needs. We believe the Water Systems Mitigation and Adaptation Partnership program contained in S. 1733 is the correct approach and will establish a foundation to help communities manage climate change impacts.that can impair our mission to protect human health and the environment.

RENEWABLE ENERGY AND POTW CONTRIBUTIONS TO SUSTAINABLE ENERGY

In addition to the important attention S. 1733 provides to focus on the impacts upon infrastructure and operations of wastewater treatment systems, we believe that energy production should also be addressed. S. 1733 offers a number of avenues to enhance our nation's ability to develop alternative energy technologies to reduce emissions. For our purposes, we contend that the alternative energy production options should not foreclose any option.

In the case of wastewater treatment operations, the process of treating wastewater generates a significant resource for energy production in the form of biosolids. According to the Water Environment Research Foundation , biosolids contain enough potential energy to meet twelve percent of the nation's energy demand. In simple terms, this is enough energy to meet the annual power needs of New York City, Houston, Dallas and Chicago. Researchers have measured the raw energy content of biosolids and determined that the embedded energy is significant and can provide for significant energy production. Use of biosolids and biogas for energy generation can lead to enhanced stewardship in the way we can reuse this resource, create new employment opportunities and reduce greenhouse gas emissions.

Currently wastewater treatment plants produce only a fraction of the energy they need to operate. In order to ensure that our renewable energy portfolio is as diverse as possible, we need to incorporate the wastewater sector into the renewable energy production effort. In the San Francisco Bay area, a coalition of local agencies has begun to examine the feasibility of using this energy resource. We believe that projects like this offer a meaningful way to minimize waste products, increase the use of green energy technology, and reduce greenhouse gas emissions. Some states, such as Massachusetts and Colorado, already allow biogas and biosolids produced through the wastewater treatment process to qualify as renewable biomass for the purposes of including this energy resource in a state's Renewable Electricity Portfolio Standard.

We urge the committee to include language that will enable all wastewater treatment utilities to participate in the national Renewable Electricity Portfolio Standard program.

CONCLUSION

We support comprehensive climate change legislation and believe S. 1733 will put us on the path toward avoiding the catastrophic impacts climate change will have on our water resources. We believe the bill addresses critical adaptation challenges facing the water sector and look forward to working with you to provide a pathway for the wastewater treatment sector to help America become energy independent. I would be pleased to respond to any questions the committee may have at this time.

RESPONSES

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

CLIMATE CHANGE HEARING FOLLOW-UP QUESTIONS

SUBMITTED BY

CALIFORNIA ASSOCIATION OF SANITATION AGENCIES

Question 1 from Senator Inhofe

I agree that many ecological and demographic changes are occurring that put a great degree of pressure on many outdated water systems, and I agree that Congress should provide more funding to help improve local water infrastructure. That's why Senators Boxer, Cardin, Crapo and I are trying to pass legislation to modernize the State Revolving Funds. A robust SRF would address many of your concerns. If the SRF bill is passed and more funds are made available to meet to state and local needs, would that alleviate many of the concerns you have expressed? In your state, we've already seen the devastating impacts of regional water struggles being exaggerated by mandated federal species protection laws that have severely restricted - and for a period of time cut off - water to many farmers and citizens in the Central Valley. Estimates are that some areas of the valley have seen unemployment levels as high as 40% and much of the valuable farmland lays fallow. My concern is this: we already have unrelenting federal laws creating absurd results, threatening private property rights, and taking huge economic tolls on local communities. Couldn't this bill's mandate that "all practical means" to protect fish and wildlife be used in litigation to undermine existing federal and state laws, agreements and contracts governing the allocation of water resources and the use of public lands? Could this new mandate be used to justify involuntary re-allocations of water, land and other resources away from current users in order to protect fish or wildlife?

Answer:

We believe the SRF bill is a good start to renew the federal partnership in environmental infrastructure assistance. However, this is a tool that targets existing needs. As most experts agree, including USEPA, these needs exceed $500 billion across the nation If the SRF funds were diluted to address other purposes like climate change, the ability of communities to rely on the SRF program to meet their existing infrastructure needs would be compromised if not constrained.

My testimony focused on the priority to address infrastructure impacts on wastewater treatment facilities. As such, we did not address the bill's impacts upon existing federal and state water contracts, rights and laws or on public lands use. As public officials involved in the treatment of wastewater to improve water quality that impact receiving waters and ecosystems, we believe that it is vital to ensure that resources are reliably available to respond to climate change impacts as detailed in our testimony. With regard to the concern posed about using mandates to shift resources involuntarily away from current users, we believe that this is a question more appropriately answered by attorneys schooled in state water laws and contracts and general naturals resources law.

Question 2:

EPA has found that passage of S 1733 – without similar GHG reductions from other nations – will not reduce overall GHG levels, thus it will not significantly reduce the impacts from alleged man-made climate change. Given this finding that climate change will occur with or without this bill, please explain how a federal cap and trade program would directly improve the performance of domestic water systems?

Answer:

As we noted in our testimony, many wastewater systems have the potential to become energy self sufficient by recapturing and reusing the methane generated on site through the treatment process. Our sector may even be able to provide a clean source of renewable energy back to the grid. In addition, wastewater utilities are currently pursuing projects and further research related to GHG reduction and sequestration. If wastewater utilities are allowed to sell offsets or credits under a cap and trade framework, this will provide a powerful market-based incentive and opportunity to accelerate the movement toward energy self-sufficiency and GHG reductions. While we believe that it is not appropriate to regulate essential public services such as wastewater utilities under a cap, we do believe that a market-based cap and trade system will advance energy efficiency and GHG reductions.

Senator BOXER. I am very proud to have that support, and I will let Senator Kerry know about your comments.

Our next witness is Dr. Peter Frumhoff, Chief Scientist, Climate Campaign, Union of Concerned Scientists.

Welcome.

STATEMENT OF PETER C. FRUMHOFF, PH.D., DIRECTOR, SCIENCE AND POLICY, AND CHIEF SCIENTIST, CLIMATE CAMPAIGN, UNION OF CONCERNED SCIENTISTS

Mr. FRUMHOFF. Thank you. Madam Chair and distinguished members of the committee, thank you for the opportunity to speak with you today.

I am Dr. Peter Frumhoff, Director of Science and Policy at the Union of Concerned Scientist and Chief Scientist of our Climate Campaign. I have been privileged to serve as a lead author on multiple reports of the Intergovernmental Panel on Climate Change and guide several assessments on climate change impacts on the United States.

The Union of Concerned Scientists strongly supports the inclusion of sound domestic and international climate adaptation investments as an essential complement to emissions reductions within the Clean Energy Jobs and American Power Act of 2009.

As you know, the U.S. National Academy of Sciences and virtually every major U.S. and international scientific body with relevant expertise have affirmed that global warming is underway now and primarily human caused.

The climate related impacts are expected to increase in severity and extent, and meeting the climate challenge requires two approaches, both swift and deep reductions in our emissions of heat trapping gases and investments in adaptation to help us cope with those impacts that are now unavoidable.

Now, the reason why adaptation is so essential is that substantial further warming is locked in due to the heat trapping gases that we have already emitted. Much of that heat has been absorbed by the earth's oceans. As the oceans release that heat, the atmosphere will continue to warm for the next several decades.

Further, the carbon dioxide that we have already released through our burning of fossil fuels and clearing of forests lingers in the atmosphere for several decades, continuing to warm the climate.

Smart investments to prepare for now unavoidable impacts are essential, for example, to ensure that our Nation's low lying coastal infrastructure from New Orleans to Boston are resilient to rising sea levels, that our public health systems can cope with more frequent extreme heat and changing disease vectors, and that our cities and industries and ecosystems can address and cope with the additional stress that climate change will increasingly place on our Nation's fresh water resources through declining snow packs and more frequent and more severe floods and droughts.

It is also directly in our national interest to help the most vulnerable developing nations cope with now unavoidable climate change. I am pleased that the proposed legislation includes provisions that support international adaptation and would respectfully submit that those investments could well be increased.

But adaptation alone is not sufficient. Beyond the next few decades, the cost, and indeed, the feasibility of adaptation, depends on how swiftly we reduce our emissions. In June of this year, a team of more than 30 of our Nation's top scientists released a major assessment of global climate change impacts on the United States. This peer-reviewed Federal report, initiated and largely carried out under the Bush administration, documents extensive impacts across our Nation if we do not swiftly reduce our heat-trapping emissions.

By the end of this century, for example, if we do not swiftly reduce emissions, extreme heat waves as severe as Chicago experienced in 1995, killing more than 700 people, are conservatively projected to occur every year in Indianapolis, Minneapolis and other Midwestern cities.

If we do not swiftly reduce emissions, an average summer in Missouri is projected to have more than 2 months of days over 100 degrees Fahrenheit. An average summer day in Pennsylvania is predicted to feel like a summer day does today in Georgia or Alabama.

If we do not swiftly reduce emissions, in Minnesota, Michigan and Wisconsin, heavy down pours, twice as frequent now as they were a century ago, are projected to increase further and cause widespread flooding, damage to infrastructure and delay planting of crops.

If we do not swiftly reduce emissions, in New York, New Hampshire, Vermont and Maine, the winter snow season is conservatively projected to be cut in half and reduced to just a week or two in Pennsylvania. The ski industry across the Northeast, for example, stands to lose up to $800 million in annual revenue.

U.S. leadership is reducing heat trapping emissions by levels and great and perhaps ultimately greater than those proposed within the Clean Energy Jobs and American Power Act, is essential to keep these and other impacts from becoming legacies of climate disruption that we leave for our children and grandchildren.

The opportunity in front of us is to reap the multiple benefits of U.S. leadership to a vibrant clean energy economy. I and my colleagues at the Union of Concerned Scientists are pleased to support this legislation and to work with this committee to ensure that the Act maintains and strengthens provisions to reduce emissions and adapt to those changes we can no longer avoid.

We strongly encourage that this historic legislation be reported out of this committee and passed by the full Senate as fully as swiftly as possible.

Further information on climate science, impacts and solutions is included in my written submission.

Thank you.

[The prepared statement of Mr. Frumhoff follows:]

TESTIMONY OF PETER C. FRUMHOFF, PH. D
DIRECTOR OF SCIENCE AND POLICY
AND
CHIEF SCIENTIST, CLIMATE CAMPAIGN
UNION OF CONCERNED SCIENTISTS
BEFORE THE
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

OCTOBER 28, 2009

Madame Chair and distinguished Members of the Committee, thank you for the opportunity to speak with you today. I am Dr. Peter Frumhoff, Director of Science and Policy at the Union of Concerned Scientists (UCS) and Chief Scientist of the UCS Climate Campaign. I have been privileged to serve as a lead author on multiple reports of the Intergovernmental Panel on Climate Change (IPCC) and guide several assessments of climate change impacts on the United States.

The Union of Concerned Scientists strongly supports the inclusion of sound domestic and international climate adaptation investments as an essential complement to emissions reductions within the Clean Energy Jobs and American Power Act of 2009 (S. 1733).

As you know, the US National Academy of Sciences, and virtually every major U.S. and international scientific body with relevant expertise has affirmed that (i) global warming is unequivocal and primarily human-caused, (ii) climate-related impacts are occurring now and are expected to increase in severity and extent, and (iii) meeting the climate challenge requires two approaches: *both* swift and deep reductions in our emissions of heat-trapping gases *and* investments in adaptation to help us cope with those impacts that are now unavoidable.

Why both? Adaptation is essential, as substantial near-term impacts are locked in due to the heat-trapping gases we have already emitted. Much of that heat has been absorbed by the earth's oceans. As the oceans release that heat, the atmosphere will further warm over the next several decades. Further, the carbon dioxide released when we burn fossil fuels and clear forests lingers in the atmosphere, continuing to trap heat for many years.

Smart investments to prepare for now unavoidable impacts are essential, for example, to ensure that our nation's low-lying coastal infrastructure are resilient to rising sea-levels; our public health systems can cope with more frequent extreme heat and changing disease vectors; and our cities and industries can manage the additional stress that climate change will increasingly place on our nation's freshwater resources through declining snow packs and more frequent and more severe floods and droughts.

It is also directly in our national interest to help the most vulnerable developing nations cope with now unavoidable climate change. I am pleased that the proposed legislation includes provisions to support international adaptation.

But adaptation alone is not sufficient. Beyond the next few decades, the cost and the *feasibility* of adaptation depend on how swiftly and deeply we reduce our emissions. In June of this year, a team of more than 30 of our nation's top scientists released a major assessment of "Global Climate Change Impacts in the United States." (Karl et al., 2009) This peer-reviewed federal report -- initiated and largely carried out under the Bush administration -- documents extensive impacts across our nation if we do not swiftly reduce our heat-trapping emissions.

By the end of this century, for example:

- Extreme heat waves as severe as Chicago experienced in 1995, killing more than 700 people, are conservatively projected to occur every year in **Indianapolis, Minneapolis**, and other Midwestern cities. (Karl et al., 2009 Page 118)

- An average summer in **Missouri** is projected to have more than two months of days over 100 degrees Fahrenheit. (Karl et al., 2009 Page 29) An average summer day in **Michigan** is projected feel like a summer day does today in Texas (Hayhoe et al., 2009).

- In **Minnesota**, **Michigan** and **Wisconsin**, heavy downpours - twice as frequent now as they were a century ago (Karl et al., 2009 Page 20) - are projected to increase further and cause widespread flooding, damage to infrastructure, and delay planting of crops

- In **New York**, **New Hampshire**, **Vermont** and **Maine**, the winter snow season is conservatively projected to be cut in half and reduced to just a week or two in **Pennsylvania** (Karl et al., 2009 Page 107) . The ski industry across the Northeast stands to lose $400-800 million in annual revenue (Ackerman and Stanton, 2009).

U.S. leadership in reducing heat-trapping emissions – by levels as great, and perhaps ultimately greater than those proposed within the Clean Energy Jobs and American Power Act – is essential to keep these and other impacts from becoming the legacies of climate disruption that we leave for our children and grandchildren.

I and my colleagues at the Union of Concerned Scientists are pleased to support this legislation, and to work with this committee to ensure that the Act (S.1733) maintains and strengthens provisions to reduce emissions and adapt to those changes that we can no longer avoid. We strongly encourage that this historic legislation be reported out of this committee and passed by the full Senate as swiftly as possible.

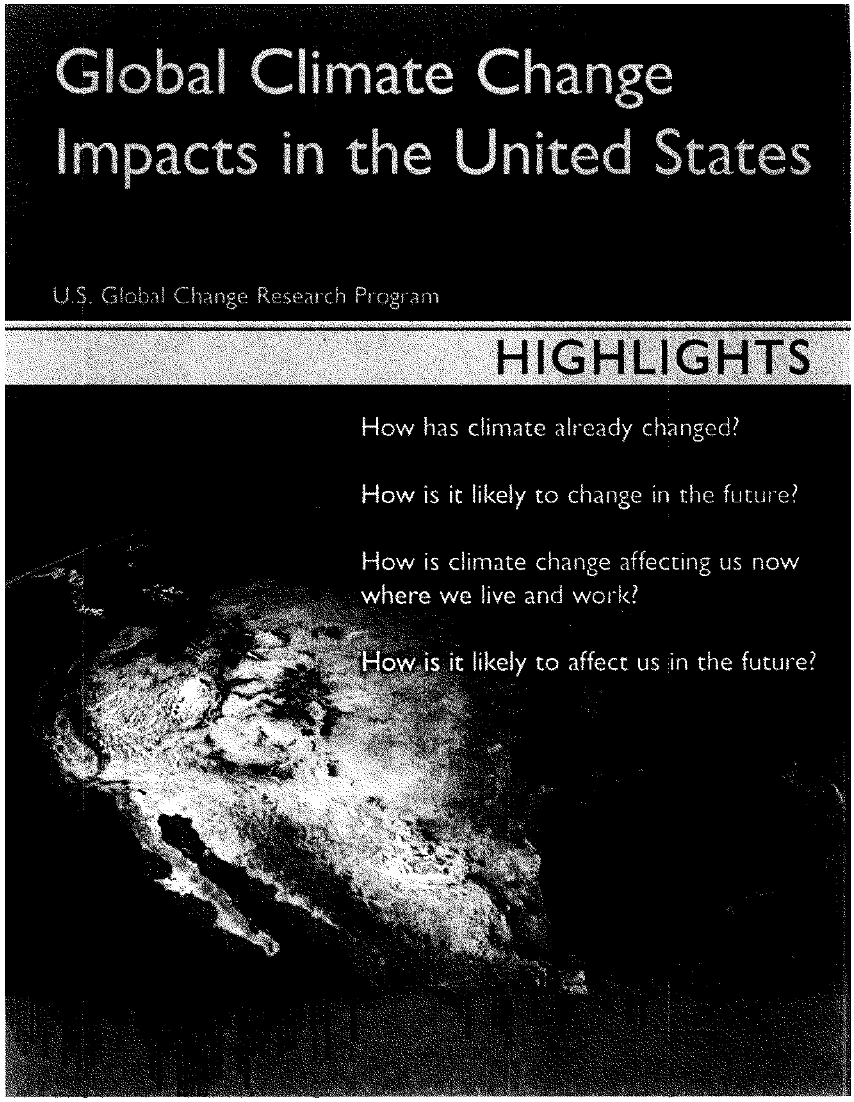
Further information on climate science, impacts and solutions is included in my written submission. Thank you.

References

Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

Ackerman, F. and E. A. Stanton, 2009. *Climate Change in the United States: The Prohibitive Costs of Inaction.* Cambridge, MA, Union of Concerned Scientists.

Hayhoe, K., J. VanDorn, V. Naik, and D. Wuebbles. 2009. *Climate change in the Midwest: Projections of future temperature and precipitation.* Cambridge, MA: Union of Concerned Scientists.



Global Climate Change Impacts in the United States

U.S. Global Change Research Program

HIGHLIGHTS

How has climate already changed?

How is it likely to change in the future?

How is climate change affecting us now where we live and work?

How is it likely to affect us in the future?

Highlights of *Global Climate Change Impacts in the United States*

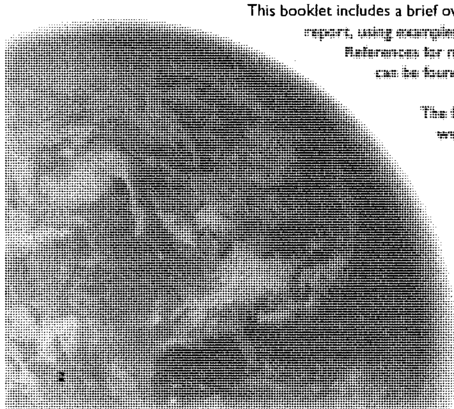
This booklet highlights key findings of *Global Climate Change Impacts in the United States*, a state of knowledge report about the observed and projected consequences of climate change for our nation and people. It is an authoritative scientific report written in plain language, with the goal of better informing public and private decision making at all levels.

The report draws from a large body of scientific information including the set of 21 synthesis and assessment products from the U.S. Global Change Research Program, the assessments of the Intergovernmental Panel on Climate Change, and much more. It also includes new information published since these assessments were released.

While the primary focus of the report is on the impacts of climate change in the United States, it also discusses some of the actions society is already taking or can take to respond to the climate challenge. These include limiting climate change by, for example, reducing emissions of heat-trapping gases or increasing their removal from the atmosphere.

The importance of our current choices about heat-trapping emissions is underscored by comparing impacts resulting from higher versus lower emissions scenarios. Choices about emissions made now will have far-reaching consequences for climate change impacts, with lower emissions reducing the magnitude of climate change impacts and the rate at which they appear.

The report also identifies examples of options currently being pursued to cope with or adapt to the impacts of climate change and/or other environmental issues. One example of adaptation is included in this booklet. There is generally insufficient information at present to evaluate the effectiveness, costs, and benefits of potential adaptation actions.



This booklet includes a brief overview of the 10 key findings of the report, using examples from the report to illustrate each finding. References for material in this booklet, including figures, can be found in the full report.

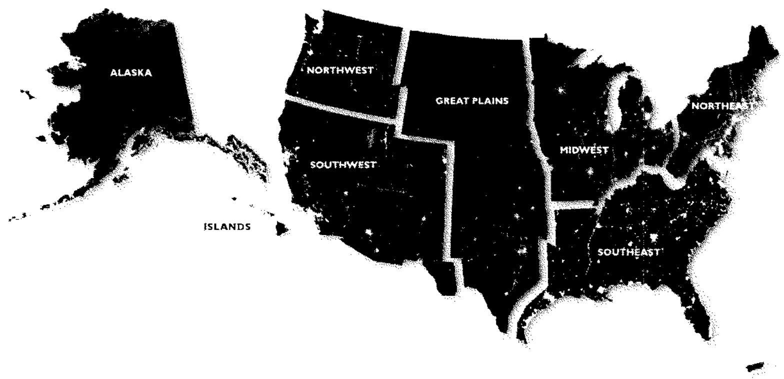
The full report can be found online at www.globalchange.gov/usimpacts

It is published by Cambridge University Press, with hard copies available at: www.cambridge.org

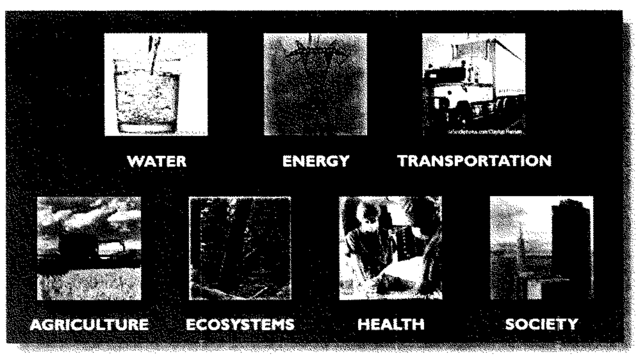
ISBN 978-0-521-14407-0

Global Climate Change Impacts in the United States describes current and future impacts of climate change on various U.S. regions and sectors.

There are both important commonalities and important differences in the climate-related issues and consequences faced around the country. For example, water is a key issue in all regions, but the specific changes and impacts vary. Regional perspectives are thus critical to thinking through responses to the changes that will be faced around the nation.



While the impacts of climate change clearly vary among the regions, there are issues of national importance that transcend regional boundaries. Seven such "sectors" (shown below) are considered in this report, providing a more integrated national picture of impacts, although one with regional differences.



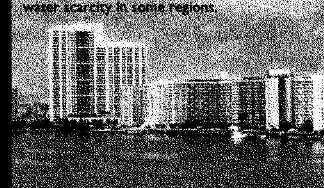
Impacts of Climate Change

Climate change is apparent now across our nation. Trends observed in recent decades include rising temperatures, increasing heavy downpours, rising sea level, longer growing seasons, reductions in snow and ice, and changes in the amounts and timing of river flows. These trends are projected to continue, with larger changes resulting from higher amounts of heat-trapping gas emissions, and smaller changes from lower amounts of these emissions. The observed changes in climate are already causing a wide range of impacts, and these impacts are expected to grow. Select examples follow.

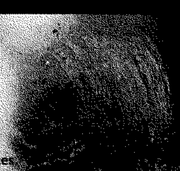
Sea Ice and Permafrost
Risks and costs in Alaska increase as thawing of permafrost damages roads, buildings, and forests, and declining sea ice increases coastal erosion and threatens the existence of some communities.

Forests
Forest growth is generally projected to increase in much of the East, but decrease in much of the West as water becomes even scarcer. Major shifts in species are expected, such as maple-beech-birch forests being replaced by oak-hickory in the Northeast. Insect infestations and wildfires are projected to increase as warming progresses.

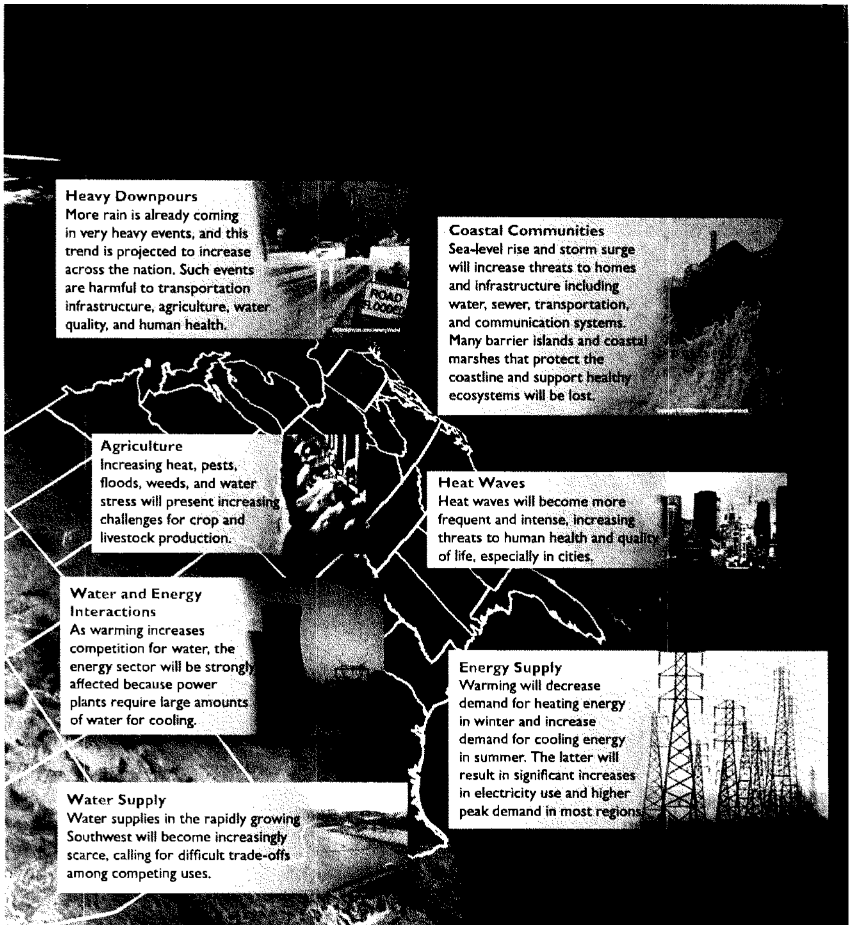
Coldwater Fish
Salmon, trout, and other coldwater fish will face additional stresses as water temperatures rise and summer streamflows decline. Ecosystems and the tourism and recreation they support will be adversely affected.



Interacting Stresses
Population shifts and development choices are making more Americans vulnerable to the impacts of climate change. An aging populace and continued population shifts to the Southeast, Southwest, and coastal cities amplify risks associated with extreme heat, sea-level rise, storm surge, and increasing water scarcity in some regions.



Coral Reefs
Rising water temperatures and ocean acidification threaten coral reefs and the rich ecosystems they support. These and other climate-related impacts on coastal and marine ecosystems will have major implications for tourism and fisheries.



Responding to Climate Change

Responses to climate change fall into two major categories. "Mitigation" focuses on reducing emissions of heat-trapping gases or increasing their uptake to reduce the amount and speed of climate change. "Adaptation" refers to changes made to better respond to present or future climate conditions in order to reduce harm or take advantage of opportunities. Both are necessary elements of a comprehensive response strategy.

TEN KEY FINDINGS

1 Global warming is unequivocal and primarily human-induced

Global temperature has increased over the past 50 years. This observed increase is due primarily to human-induced emissions of heat-trapping gases.

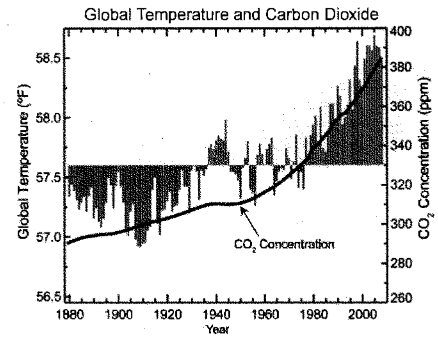
The emissions responsible for human-induced warming come primarily from the burning of fossil fuels (coal, oil, and gas) with additional contributions from the clearing of forests and agricultural activities.

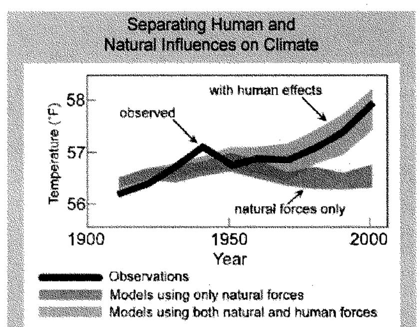
Global average temperature has risen by about 1.5°F since 1900. By 2100, it is projected to rise another 2 to 11.5°F. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are cut substantially. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range.

As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years. In the absence of strong control measures, emissions projected for this century would result in the carbon dioxide concentration increasing to a level that is roughly 2 to 3 times the highest level occurring over the last 800,000 or more years.

Human activities have been clearly linked to many aspects of climate change including:

- Temperature
- Precipitation
- Ocean heat content
- Atmospheric moisture
- Arctic sea ice



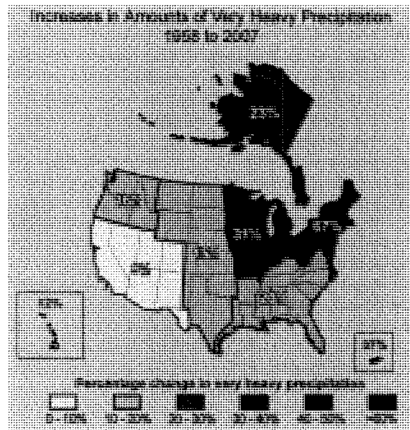


As the blue band indicates, without human influences, global average temperature would actually have cooled slightly over recent decades. With human influences, it has risen strongly (black line), consistent with expectations from climate models (pink band).

2 Climate changes are underway in the United States and are projected to grow

Changes observed in the U.S. include:

- **Temperature rise**
- **Sea-level rise**
- **Increase in heavy downpours**
- **Rapidly retreating glaciers**
- **Thawing permafrost**
- **Longer growing season**
- **Longer ice-free season in the ocean and on lakes and rivers**
- **Earlier snowmelt**
- **Changes in river flows**



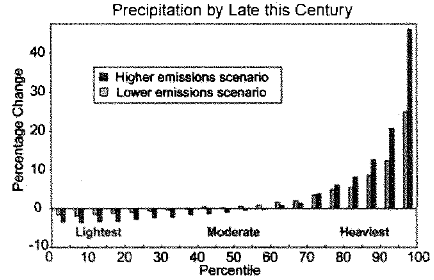
Heavy Downpours

One of the most striking changes in climate observed over the United States has been an increase in the frequency and intensity of heavy downpours. This increase was responsible for most of the observed increase in overall precipitation during the last 50 years. The amount of precipitation falling in the heaviest 1 percent of rain events increased nearly 20 percent. During the past 50 years, the largest increases in heavy precipitation occurred in the Northeast and the Midwest.

Climate models project continued increases in the heaviest downpours during this century, while the lightest precipitation is projected to decrease. The chart below shows the projected changes in each category of precipitation, from lightest to heaviest, under increasing emissions of heat-trapping gases. Much larger increases in heavy downpours are projected under higher emissions scenarios than under lower emissions scenarios.

A note on the emissions scenarios:
None of the emissions scenarios used in this report assumes any policies specifically designed to address climate change. All, including the lower emissions scenario, assume increases in heat-trapping gas emissions for at least the next few decades, though at different rates. The "lower emissions scenario" used in this report is the B1 scenario from the Intergovernmental Panel on Climate Change (IPCC). The "higher emissions scenario" is A2. Elsewhere, a third "even higher emissions scenario" is used, IPCC's A1FI.

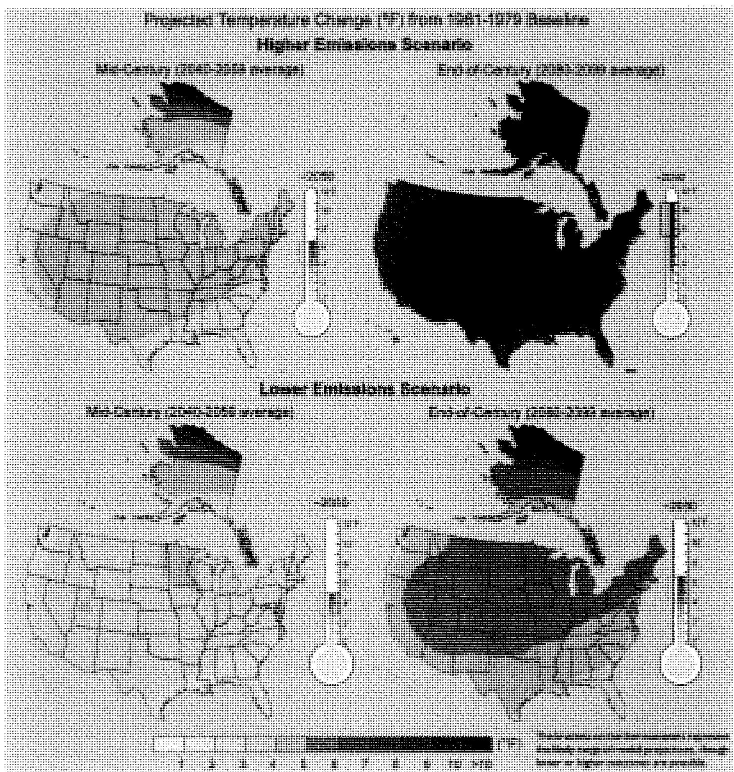
Projected Changes in Light, Moderate, and Heavy Precipitation by Late this Century



2 Climate changes are underway in the U.S. and are projected to grow

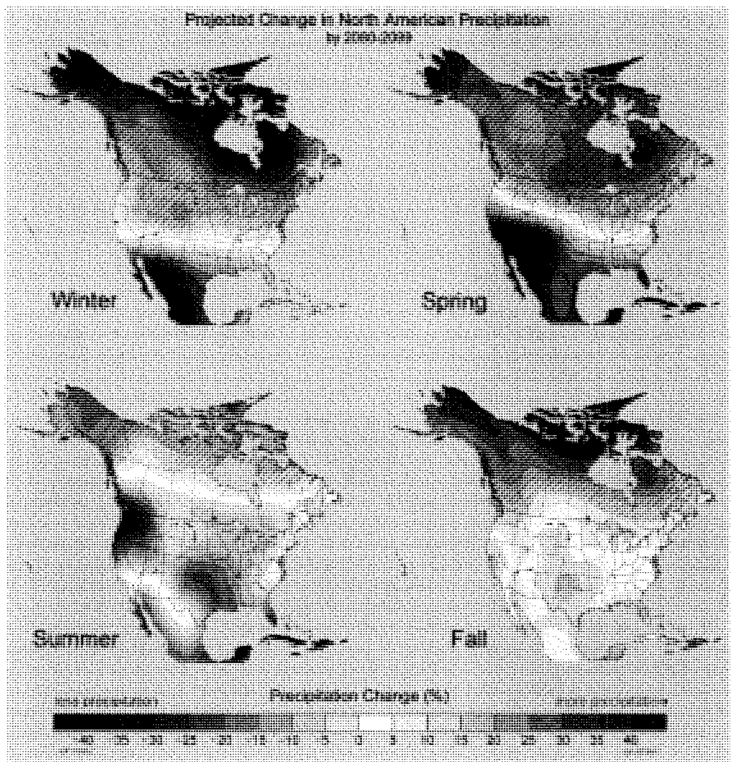
Rising Temperature

U.S. average temperature has increased by about 2°F over the past 50 years, which is more than the global average temperature increase. In the next couple of decades, another degree or so of temperature rise is projected. The maps below show projected temperature increases for the middle and the end of this century, under both higher and lower emissions scenarios. As the maps illustrate, the higher the emissions, the higher the temperature increases. If actual emissions are lower than those represented in the lower emissions scenario, temperature increases would be smaller than those shown on the bottom set of maps.



Changing Precipitation Patterns

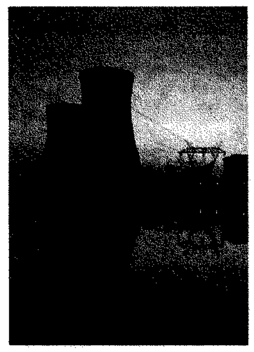
The maps below show projected future changes in precipitation relative to the recent past as simulated by 15 climate models. The simulations are for late this century, under a higher emissions scenario, with blue indicating increasing precipitation, and brown indicating decreasing precipitation. For example, in the spring, climate models agree that northern areas are likely to get wetter, and southern areas drier. There is less confidence in exactly where the transition between wetter and drier areas will occur. Confidence in the projections is highest in the hatched areas.



3 Widespread climate-related impacts are occurring now and are expected to increase

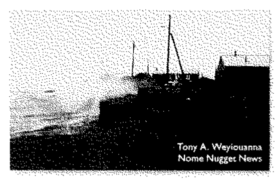
Energy Supply and Use

- Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. The latter will result in significant increases in electricity use and higher peak demand in most regions.
- Energy production is likely to be constrained by rising temperatures and limited water supplies in many regions.
- Energy production and delivery systems are exposed to sea-level rise and extreme weather events in vulnerable regions.
- Climate change is likely to affect some renewable energy sources across the nation, such as hydropower production in regions subject to changing patterns of precipitation or snowmelt.



Society

- Population shifts and development choices are making more Americans vulnerable to the expected impacts of climate change.
- Vulnerability is greater for people who have few resources and few choices.
- City residents and city infrastructure have unique vulnerabilities to climate change.
- Climate change affects communities through changes in climate-sensitive resources that occur both locally and at great distances.
- Insurance is one of the industries particularly vulnerable to increasing extreme weather events such as severe storms, but it can also help society manage the risks.
- The United States is connected to a world that is unevenly vulnerable to climate change and thus will be affected by impacts in other parts of the globe.

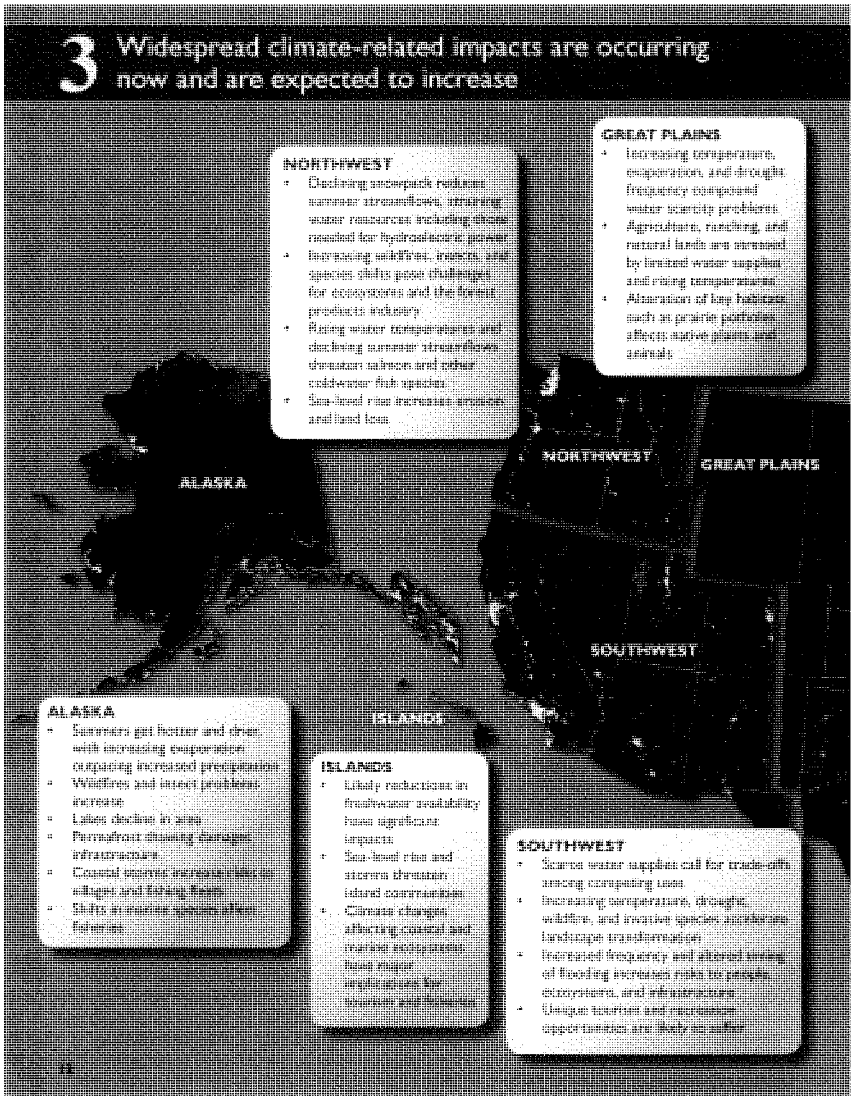


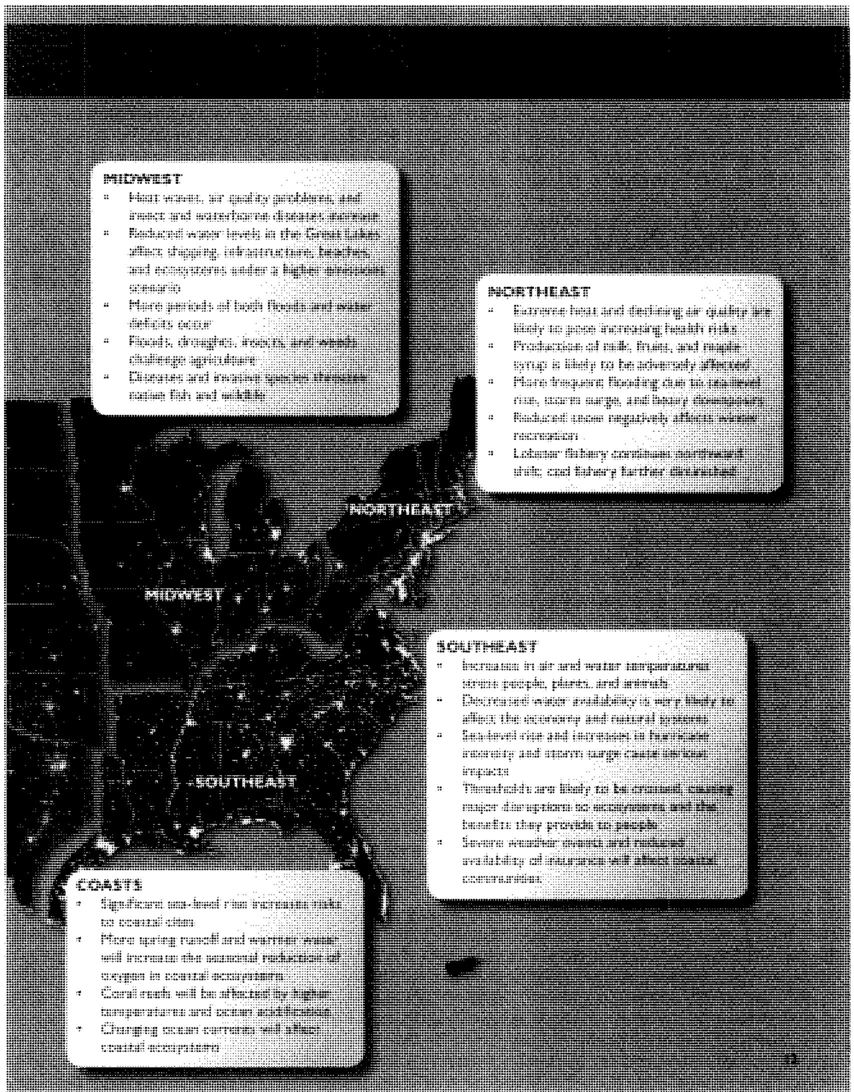
Ecosystems

- Ecosystem processes, such as those that control growth and decomposition, have been affected by climate change.
- Large-scale shifts have occurred in the ranges of species and the timing of the seasons and animal migration, and are very likely to continue.
- Fires, insect pests, disease pathogens, and invasive weed species have increased, and these trends are likely to continue.
- Deserts and drylands are likely to become hotter and drier, feeding a self-reinforcing cycle of invasive plants, fire, and erosion.
- Coastal and near-shore ecosystems are already under multiple stresses. Climate change and ocean acidification will exacerbate these stresses.
- Arctic sea ice ecosystems are already being adversely affected by the loss of summer sea ice and further changes are expected.
- The habitats of some mountain species and coldwater fish, such as salmon and trout, are very likely to contract in response to warming.
- Some of the benefits ecosystems provide to society will be threatened by climate change, while others will be enhanced.

Transportation

- Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, roads, rail lines, and tunnels.
- Flooding from increasingly intense downpours will increase the risk of disruptions and delays in air, rail, and road transportation, and damage from mudslides in some areas.
- The increase in extreme heat will limit some transportation operations and cause pavement and track damage. Decreased extreme cold will provide some benefits such as reduced snow and ice removal costs.
- Increased intensity of strong hurricanes would lead to more evacuations, infrastructure damage and failure, and transportation interruptions.
- Arctic warming will continue to reduce sea ice, lengthening the ocean transport season, but also resulting in greater coastal erosion due to waves. Permafrost thaw in Alaska will damage infrastructure. The ice road season will become shorter.


3 Widespread climate-related impacts are occurring now and are expected to increase
NORTHWEST
• Declining snowpack reduces summer streamflows, straining water resources including those needed for hydroelectric power
• Increasing wildfires, insects, and species shifts pose challenges for ecosystems and the forest products industry
• Rising water temperatures and declining summer streamflows threaten salmon and other coldwater fish species
• Sea-level rise increases erosion and land loss
GREAT PLAINS
• Increasing temperature, evaporation, and drought frequency compound water scarcity problems
• Agriculture, ranching, and natural lands are stressed by limited water supplies and rising temperatures
• Alteration of key habitats such as prairie potholes affects native plants and animals
ALASKA
NORTHWEST
GREAT PLAINS
SOUTHWEST
ISLANDS
ALASKA
• Summers get hotter and drier with increasing evaporation outpacing increased precipitation
• Wildfires and insect problems increase
• Lakes decline in area
• Permafrost thawing damages infrastructure
• Coastal storms increase risks to villages and fishing fleets
• Shifts in marine species affect fisheries
ISLANDS
• Likely reductions in freshwater availability have significant impacts
• Sea-level rise and storms threaten island communities
• Climate changes affecting coastal and marine ecosystems have major implications for tourism and fisheries
SOUTHWEST
• Scarce water supplies call for trade-offs among competing uses
• Increasing temperature, drought, wildfire, and invasive species accelerate landscape transformation
• Increased frequency and altered timing of flooding increases risks to people, ecosystems, and infrastructure
• Unique tourism and recreation opportunities are likely to suffer
12


MIDWEST
NORTHEAST
SOUTHEAST
COASTS
NORTHEAST
MIDWEST
SOUTHEAST

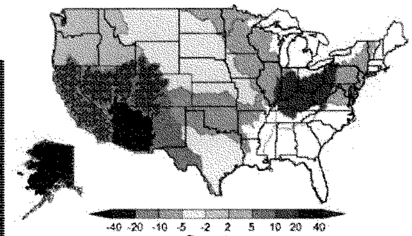
4 Climate change will stress water resources

Water is an issue in every region, but the nature of the potential impacts varies. Drought – related to reduced precipitation, increased evaporation, and increased water loss from plants – is an important issue in many regions, especially in the West. Floods and water quality problems are likely to be amplified by climate change in most regions. Declines in mountain snowpack are important in the West and Alaska where snowpack provides vital natural water storage.

Climate change affects water resources:

- Water cycle is altered, affecting where, when, and how much water is available
- Floods and droughts become more common and intense as regional and seasonal precipitation patterns change and rainfall is more concentrated into heavy events with longer dry periods in between
- Less snow, more rain
- Wet areas get wetter, dry areas get drier
- Mountain snowpack declines, timing of runoff shifts to earlier in spring, and flows are lower in summer
- Increased competition for water supplies

Projected Changes in Annual Runoff

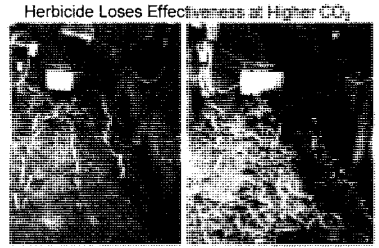


Runoff is the amount of precipitation that is not evaporated, stored as snowpack or soil moisture, or filtered down to groundwater. Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water resource region. Colors indicate percentage changes in runoff. Hatched areas indicate greater confidence due to strong agreement among model projections. White areas indicate divergence among model projections.

5 Crop and livestock production will be increasingly challenged

- Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.
- Extreme events such as heavy downpours and droughts are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.
- Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.
- Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed.
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

Weed Growth is Promoted and Herbicide Loses Effectiveness at Higher CO_2

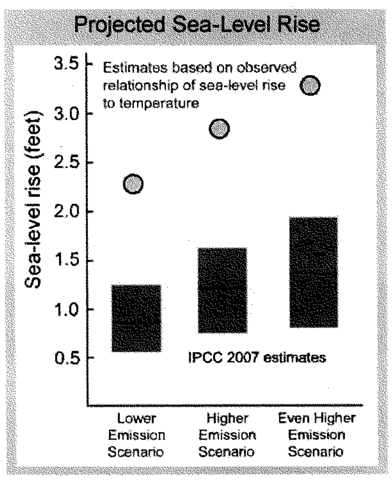


Current CO_2 (380 ppm) Potential Future CO_2 (680 ppm)

6 Coastal areas are at increasing risk from sea-level rise, storm surge, and other climate-related stresses

Coastal impacts include:

- **Sea-level rise leads to erosion and loss of land**
- **Storm surge causes flooding**
- **Increased pollution due to more runoff from the land**
- **Ocean acidification threatens coral reefs and shellfish**



Based on the state of the science at the time, in 2007 the Intergovernmental Panel on Climate Change (IPCC) projected a rise of the world's oceans from 8 inches to 2 feet by the end of this century (range shown as bars). However, they could not quantify the contributions to sea-level rise due to changes in ice sheet dynamics. More recent research has attempted to quantify this contribution by estimating future sea level based on its observed relationship to temperature. For example, the projections indicated by the light blue circles in the figure above estimate global average sea-level rise of almost 3.5 feet by the end of this century under a high emissions scenario. In areas where the land is sinking, such as the Atlantic and Gulf Coasts of the United States, sea-level rise will be higher than the global average.

Global sea level is rising due to the warming-induced expansion of ocean water, accelerated melting of most of the world's glaciers, and loss of ice from the Greenland and Antarctic ice sheets. Additional warming will cause further sea-level rise over this century and beyond.

Rising sea level is already eroding shorelines, drowning wetlands, and threatening homes, businesses, and infrastructure. The destructive potential of Atlantic hurricanes has increased in recent decades in association with increasing sea surface temperatures, and it is likely that hurricane rainfall and wind speeds will increase in response to global warming. Coastal water temperatures have risen and the geographic distributions of marine species have shifted.

Precipitation increases on land have increased river runoff, polluting coastal waters with more nitrogen and phosphorous, sediments, and other contaminants. Ocean acidification resulting from the uptake of carbon dioxide by ocean waters threatens corals, shellfish, and other living things that form their shells and skeletons from calcium carbonate.

All of these forces converge and interact at the coasts, making these areas particularly sensitive to the impacts of climate change.

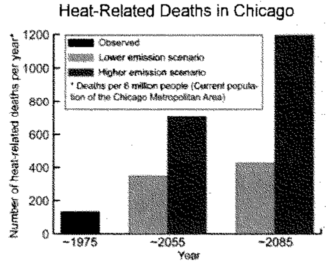
7 Threats to human health will increase

Major health risks include:

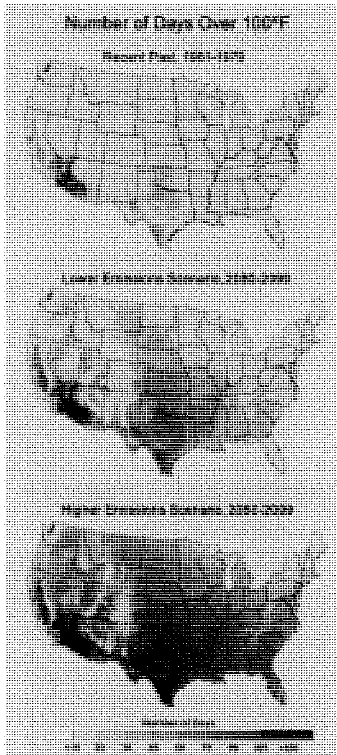
- Heat stress
- Waterborne diseases (due to heavy downpours and higher temperatures)
- Poor air quality
- Extreme weather events
- Diseases caused by insects and rodents
- Pollen increases
- Children, the elderly, and the poor are most vulnerable to climate-related health effects

Climate change poses unique challenges to human health including heat waves and severe storms, ailments caused or exacerbated by air pollution and airborne allergens, and many climate-sensitive infectious diseases. Whether or not increased health risks due to climate change are realized will depend largely on societal responses and underlying vulnerability. The probability of exacerbated health risks due to climate change points to a need to maintain a strong public health infrastructure to belp limit future impacts.

Projected Increase in
Heat-Related Deaths in Chicago



Increases in heat-related deaths are projected in cities around the nation, especially under higher emissions scenarios. This analysis included some adaptation measures. The graph shows the projected number of deaths per year, averaged over a three-decade period around 1975, 2055, and 2085 for the City of Chicago under lower and higher emissions.



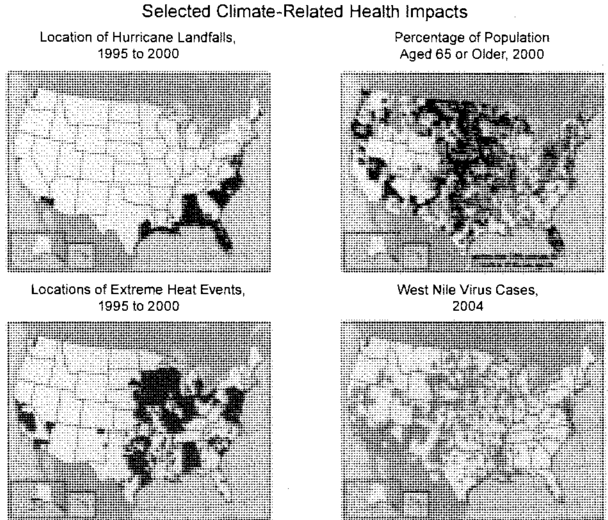
High air temperatures are uncomfortable, stressful, and increase the risk of heat-related illnesses. The number of days in which the temperature exceeds 100°F by late this century, compared to the 1960s and 1970s, is projected to increase strongly across the United States.

8 Climate change will interact with many social and environmental stresses

Social trends can increase our vulnerability to climate change. Recent trends include concentration of development along vulnerable coasts, aging of the U.S. population, increasing urbanization, and population growth in the South and West. Overlaying projections of future climate change and its impacts on expected changes in U.S. population and development patterns reveals a critical insight: More Americans will be living in the areas that are most vulnerable to the effects of climate change, from sea-level rise and hurricanes in the Southeast, to water scarcity in the Southwest.

Pollution and the resulting poor air quality is one of many human-caused stresses that interact with climate change to amplify impacts. The combination of air pollution with heat, drought, and stagnant air negatively affects human health and quality of life in cities.

Geographic Vulnerability of U.S. Residents to Selected Climate-Related Health Impacts



Maps indicating U.S. counties, or in some cases states, with existing vulnerability to climate-sensitive health outcomes. These examples demonstrate both the diversity of climate-sensitive health outcomes and the geographic variability of where they occur.

9 Thresholds will be crossed, leading to large changes in climate and ecosystems

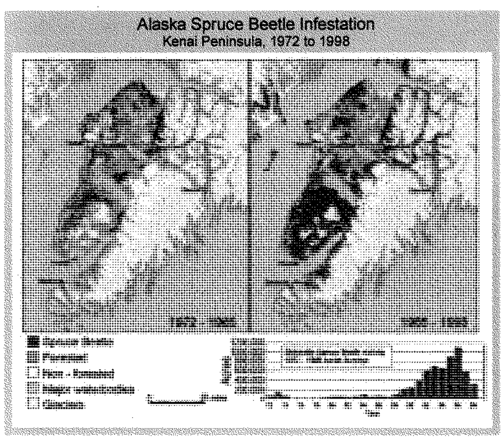
There are a variety of thresholds in the climate system and ecosystems. These thresholds determine, for example, the presence of sea ice and permafrost, and the survival of species, from fish to insect pests, with implications for society. With further climate change, the crossing of additional thresholds is expected.

Land subsidence (sinking) associated with the thawing of **permafrost** in Alaska, in addition to damaging forests and other natural systems, presents substantial challenges to engineers attempting to preserve infrastructure.

Cod in the North Atlantic are adapted to annual average temperatures near the seafloor ranging from 36 to 54°F. Large populations of cod are generally not found above the 54°F threshold. Temperature also influences the location and timing of spawning, which in turn affect the growth and survival of young cod. Increases in bottom temperatures above 47°F are projected to lead to a decline in growth and survival. Projections of warming indicate that both the 47°F and the 54°F thresholds will be met or exceeded in this century under a higher emissions scenario.

Lobster catches in the southern part of the Northeast region have declined sharply in the past decade, associated with a temperature-sensitive bacterial shell disease. The southern extent of the commercial lobster harvest appears to be limited by this disease, the effects of which are expected to increase with rising near-shore water temperatures.

Crossing key temperature thresholds has contributed to major **insect outbreaks** that have destroyed millions of acres of trees in the United States. First, warmer winters allow larger populations of insects to survive the cold season that normally limits their numbers. Second, the longer warm season allows them to develop faster, sometimes completing two life cycles instead of one in a single growing season. Third, warmer conditions allow insects' ranges to expand northward. Fourth, drought stress reduces trees' ability to resist insect attack (for example, by pushing back against boring insects with the pressure of their sap).



Spruce beetle, pine beetle, spruce budworm, and woolly adelgid (which attacks eastern hemlocks) are just some of the insects that are proliferating in the United States, causing devastation in many forests. These outbreaks are projected to increase with ongoing warming. Trees killed by insects also provide more dry fuel for wildfires.

10 Future climate change and its impacts depend on choices made today

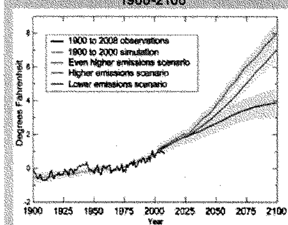
The amount and rate of future climate change depends primarily on current and future human-caused emissions of heat-trapping gases and airborne particles. Responses involve reducing emissions to limit future warming, and adapting to the changes that are unavoidable.

Human-induced climate change is happening now, and impacts are already apparent. Greater impacts are projected, particularly if heat-trapping gas emissions continue unabated. Previous assessments have established these facts, and this report confirms, solidifies, and extends these conclusions for the United States. It reports the latest understanding of how climate change is already affecting important sectors and regions. In particular, it reports that some climate change impacts appear to be increasing faster than previous assessments had suggested.

Choices about emissions now and in the coming years will have far-reaching consequences for climate change impacts. A consistent finding of this assessment is that the rate and magnitude of future climate change and resulting impacts depend critically on the level of global atmospheric heat-trapping gas concentrations. Lower emissions of heat-trapping gases will delay the appearance of climate change impacts and lessen their magnitude. Unless the rate of emissions is substantially reduced, impacts are expected to become increasingly severe for more people and places.

Similarly, there are choices to be made about adaptation strategies that can help to reduce or avoid some of the undesirable impacts of climate change. One such example is shown below and other examples appear in the full report. There is much to learn about the effectiveness of the various types of adaptation responses and how they will interact with each other and with mitigation actions.

Global Average Temperature 1900-2100



Observed and projected changes in the global average temperature under three IPCC emissions scenarios that assume no policies to address climate change. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. A wider range of model types shows outcomes from 2 to 11.5°F. Changes are relative to the 1960-1979 average.

As our nation strives to develop effective strategies to respond to climate change, it is essential to have the latest and best scientific information about the impacts of climate change in the United States. The report highlighted in this booklet provides that information.

[illegible] Raising a Sewage Treatment Plant in Boston

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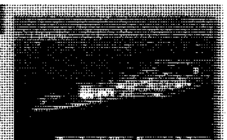

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June 2009

Union of Concerned Scientists

Climate Change in the United States

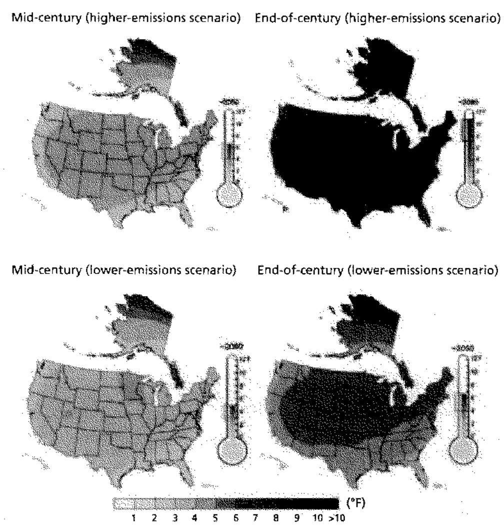
The Prohibitive Costs of Inaction

The United States is already experiencing the effects of climate change, and these effects will be much worse without action to sharply curtail our global warming emissions. Average U.S. temperatures have already risen by 2°F over the past 50 years, and are projected to rise another 7–11°F by the end of this century under a high-emissions scenario, and 4–6.5°F under a low-emissions scenario (see Figure 1).

Recognizing the urgency of global warming, policy makers are beginning to pursue solutions to help us avoid the worst effects of climate change, while transitioning the nation to a clean energy economy. However, the debate over comprehensive climate and energy policy often focuses on the costs of climate *action*, rather than on the serious economic and environmental consequences if we *fail to act*. One study shows that if global warming emissions continue to grow unabated—a high-emissions scenario—the annual economic impact of more severe hurricanes, residential real-estate losses to sea-level rise, and growing water and energy costs could reach 1.4 percent of GDP by 2025, and 1.9 percent by 2100 (Ackerman and Stanton 2008).

The U.S. Global Change Research Program, a consortium of 13 federal departments and agencies, recently released a comprehensive report describing some of the major impacts of climate change in the United States (Karl, Melillo, and Peterson 2009). That report bolstered a growing consensus that the nation can reap significant economic, public health, and environmental benefits from moving quickly to dramatically reduce our global warming emissions.

FIGURE 1. Nationwide Projected Temperature Increases



Source: Adapted from Karl, Melillo, and Peterson 2009.

Temperatures have already risen an average 2°F over the past 50 years in the United States. By the end of the century, the average U.S. temperature is projected to increase approximately 7 to 11°F from the 1961–1979 baseline under a high-emissions scenario, and approximately 4 to 6.5°F under a low-emissions scenario.

This fact sheet provides specific examples from that and numerous other studies of the projected damages from climate change, and their costs. These studies show that climate change will have costly effects on our coasts, our health, our energy and water resources, our agriculture, our transportation infrastructure, and our recreational resources. There are other costs, not included here,

PHOTOS: (left to right) iStockphoto.com, IndexOpen.com, iStockphoto.com, USDA, BLM.

that are hard to quantify or project. The costs presented here also do not include the considerable effects on other countries. Past emissions of heat-trapping gases have already committed us to many near-term costs. However, swift and deep emissions reductions can greatly curtail longer-term costs.

Even a partial accounting of the costs sends a clear message: *Climate inaction is simply too costly.* The prudent response is to aggressively reduce carbon emissions—at least 80 percent from 2005 levels by 2050.

Climate change and ensuing sea-level rise threaten to increase the severity of flooding and to damage the infrastructure of coastal communities.

Impacts on Coastal Communities

Most of the U.S. coast has seen rising sea levels over the past 50 years, and that trend will likely continue under a warming climate. A two-foot rise in global sea levels by the end of this century—within the range of recent estimates—would mean that the ocean would rise another 2.3 feet at New York City, 2.9 feet at Hampton Roads, VA, 3.5 feet at Galveston, TX, and one foot at Neah Bay, WA (Karl, Melillo, and Peterson 2009). These changes would have serious economic consequences for coastal communities.

Flood damage. One-sixth of the U.S. population—53 million people—lives in the coastal counties of the Northeast. A sea-level rise of 13–20 inches by 2100 would threaten insured property in these counties valued at $4.7 trillion—accounting for half of the value of all insured coastal property in the United States (Frumhoff et al. 2007).

In Boston alone, 18 inches of sea-level rise are projected to exact cumulative costs of $13 billion by 2100—on top of $7 billion in "normal" flooding costs. And if sea-level rise reaches 33 inches by 2100, today's 100-year coastal flood will likely occur every one to two years in Boston and Atlantic City, and every 11 to 22 years in New York City (Frumhoff et al. 2007).

In Florida, with 45 inches of sea-levels rise projected under a high-emissions scenario, losses of residential real estate are projected to reach $60 billion annually by 2100 (Stanton and Ackerman 2007). In North Carolina, 18 inches of sea-level rise would cause $2 billion in cumulative property damage by that date (Karetnikov et al. 2008a).

In Florida, under a high-emissions scenario, 9 percent of the state's land area, 70 percent of Miami-Dade County, half of the state's existing beaches, and 99 percent of its mangroves would fall into the zone most vulnerable to year-round flooding in 2060 (Stanton and Ackerman 2007). With more coastline than the other 49 states combined, Alaska also stands to experience steep costs from rising sea levels.

Even a partial accounting of the costs sends a clear message: Climate inaction is simply too costly.

Hurricane intensity. With all other factors being equal, experts expect higher ocean temperatures to strengthen hurricanes, which can strike almost anywhere in the Southeast and Gulf Coast region, taking lives and causing enormous damage. A major northeastern hurricane like the one that struck Long Island and New England in 1938 would cause $20 billion in damages were it to strike today (Frumhoff et al. 2007).

In Florida, the annual costs of more extensive hurricane damage under a high-emissions scenario are projected to reach $111 billion by 2100. Climate change is also projected to cause an additional 37 hurricane-related deaths per year in that state by 2100—on top of today's annual average of eight deaths (Stanton and Ackerman 2007).

Adaptation costs. Protective measures to head off coastal flooding from rapidly rising sea levels will be costly. Most coastal communities will have to choose among several options: elevating existing structures, constructing seawalls or dykes, and relocating the most vulnerable families and businesses to higher ground (Titus et al. 1991). In California alone, protecting low-lying coastal property from sea-level rise and the resulting storm surges, particularly around San Francisco Bay, could cost $6 billion–$30 billion annually by 2100 under a high-emissions scenario (Kahrl and Roland-Holst 2008).

Elevating a single-family home by 24 inches could cost $22–$62 per square foot, while raising larger structures would be far more costly. Estimates of the cost of protecting vulnerable coastal areas with seawalls vary considerably. By one estimate, seawalls could cost $5 million per linear mile, totaling $1.2 billion for urban areas in the Northeast, $3.4 billion for all urban waterfront in the United States, and $60 billion to protect the entire vulnerable U.S. coastline (USGS 2000; Burby and Nelson 1991). Another study estimates that building seawalls to protect the nation from coastal flooding would cost $46 billion–$146 billion (Stanton and Ackerman 2007). However, seawalls would be ineffective against permanent flooding caused by sea-level rise without constant pumping of rain and groundwater within the walled areas (Burby and Nelson 1991; Titus et al. 1991).

In many coastal communities, the only viable option in the face of several feet of sea-level rise will be to gradually abandon properties and relocate further inland. The Army Corps of Engineers recently estimated that relocating just three Alaskan towns threatened by rising sea levels—Shismaref, Kivalina, and the village of Newtok—would cost $405 million (Ruth, Coelho, and Karetnikov 2007).

Impacts on Public Health

If emissions continue to grow unabated, extreme heat waves that now occur once every 20 years are projected to occur about every other year in much of the country by the end of this century. And these very hot days will likely be about 10°F hotter than they are today (Gutowski et al. 2008).

In July 1993, a two-week-long heat wave in Philadelphia with high temperatures between 93°F and 101°F killed more than 100 people (Frumhoff et al. 2007). Such impacts will increase dramatically with climate change, especially affecting vulnerable populations such as children, the elderly, the sick, and the poor. Although deaths from extreme cold are expected to drop, this decline will be substantially smaller than the increase in deaths from heat waves (Medina-Ramon and Schwartz 2007). And higher temperatures will create the conditions for rising levels of lung-damaging low-altitude ozone and respiratory allergies in urban areas (Twilley et al. 2001).

Heat waves. Northeast cities have historically had fewer than two days each year with temperatures above 100°F, and 5 to 20 days with temperatures above 90°F, depending on the city. Under a high-emissions scenario, many cities in this region can expect 60 or more days above 90°F by 2100, and 14–28 days above 100°F, with some of the hottest temperatures expected in large cities such as Philadelphia and New York (Frumhoff et al. 2007).

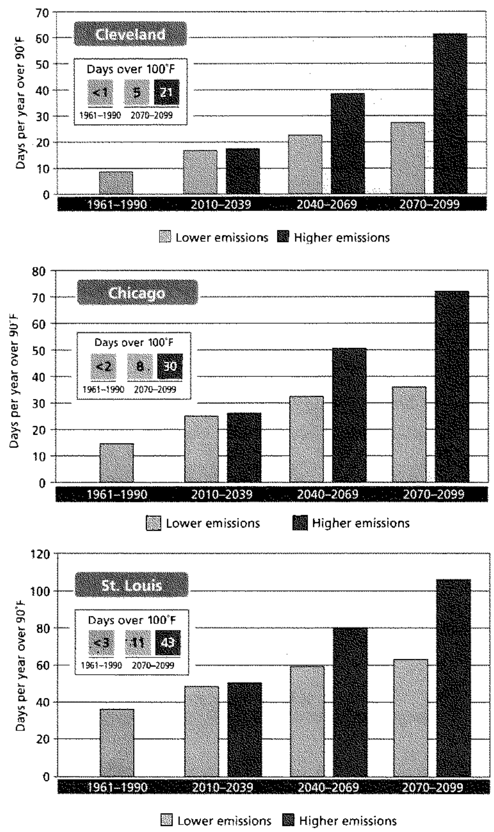
If emissions continue to grow unabated, extreme heat waves that now occur once every 20 years are projected to occur about every other year in much of the country by the end of this century.

Children and the elderly are particularly vulnerable to illness during heat waves. Urban areas across the country will experience the worst effects of heat waves, stressing hospital capacity.

The Midwest is also vulnerable to much hotter summers under both high-emissions and low-emissions scenarios, with some of the highest temperatures occurring in urban areas such as Cleveland and St. Louis (see Figure 2, p. 4). During the peak of the Chicago heat wave of 1995, admissions to Cook County hospitals rose 11 percent, to 1,072 patients (Semenza et al. 1999). A heat wave of that magnitude 10 years later would cost $18 million, given the average cost per hospitalized patient in 2005 (HCUP n.d.). Accounting for lost work days and productivity among patients and their caregivers, as well as follow-up medical appointments, would bring this cost even higher (Srinivasan 2008).

Heat waves will also become more severe and common in the Southeast and Gulf states. Miami will become

FIGURE 2. Extreme Heat in Midwestern Cities



Under a high-emissions scenario, Midwest cities will spend most of the summer sweltering in heat over 90°F, including dramatic increases in the number of days over 100°F. Making the choice to pursue a lower-emissions pathway can significantly lessen these effects.

several degrees hotter than Bangkok today—now the world's hottest, most humid major city—and daily highs in many Florida cities could exceed 90°F nearly two-thirds of the year (Stanton and Ackerman 2007). In Baton Rouge, Birmingham, Dallas, Houston, and Tampa, deaths from extreme heat now average 28 per year. Even moderate temperature increases would raise this figure to 60 to 75 deaths every year in each of those cities (Twilley et al. 2001).

Higher ozone levels. Given the same level of air pollution as today, analysts project a 68 percent increase in the number of Red Ozone Alert Days—when the air is unhealthy for everyone—in the 50 largest eastern U.S. cities by the middle of this century (Bell et al. 2007).

In New Mexico, annual health costs from low-altitude ozone and heat waves combined are expected to jump by $1.6 billion by 2080 (Niemi 2009a). In California, heat-related health costs could total $14 billion by 2100 under a high-emissions scenario, while rising ozone levels could increase medical costs by another $10 billion (Kahrl and Roland-Holst 2008).

Impacts on Water Resources

Climate change will make storms, floods, and droughts more likely and more intense, and the timing of precipitation could be seriously altered around the country. For example, precipitation and runoff are likely to increase in the Northeast and Midwest in winter and spring, and decrease in the West, especially the Southwest, in spring and summer (Karl, Melillo, and Peterson 2009).

Flooding. With its major river systems and relatively high precipitation, the Midwest is prone to flooding, with heavy rainstorms and rapid snowmelt, in particular, causing widespread damage. For example, in May and June 2008, thunderstorms, tornadoes, and flooding caused more than $18 billion in damage and 55 deaths nationwide, primarily in the Midwest (Lott et al. 2009). And in 1996, a 17-inch rainstorm caused flash flooding over more than 12,000 square miles of Illinois, Wisconsin, and Indiana in a matter of hours (Changnon 2005).

The record-breaking 1993 midwestern flood caused $30 billion of damages (Lott et al. 2009), with Iowa, Illinois and Missouri the most heavily hit states (Changnon 2005). The flood inundated 20 million acres in nine states, causing crop losses of 12 percent in Missouri, 11 percent in Minnesota, and 7 percent in Iowa (Mattoon 2008). That flood also caused an estimated 52 deaths, damaged 70,000 homes and buildings, and left 74,000 people homeless. Damages to infrastructure included 1,000 miles of roads closed, 500 miles of railroad track underwater, and nine non-railroad bridges damaged and closed. The flood also idled more than 2,000 barges on the Mississippi for two months (Mattoon 2008; Daniels and Trebilcock 2006).

A senior official at the U.S. Department of Agriculture's Risk Management Agency estimated that payments from the Federal Crop Insurance Program (FCIP) for crops damaged by a similar flood today would be five times the $2 billion paid in 1993—and not all farmers were insured through FCIP for that flood (USGAO 2007).

Water scarcity. Water shortages, already a critical issue in the Southwest, are likely to become far worse with climate change. Such shortages will make agricultural production more expensive, force cutbacks in the amount of land under cultivation, and increase the cost of living in the urban Southwest (see Figure 3). Rivers such as the Colorado—primarily supplied by snowmelt and already over-allocated—are especially vulnerable. In New Mexico alone, reduced stream flows could cost farmers $21 million per year by 2080, according to one analysis (Niemi 2009a).

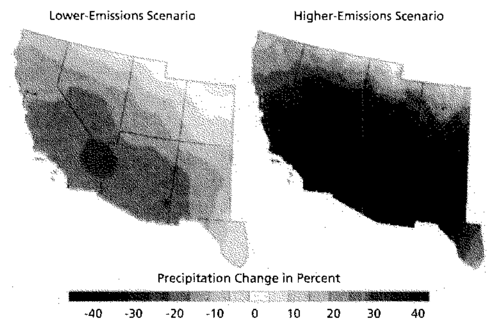
In the Southeast, annual rainfall will likely become more variable and could drop, with longer dry spells worsening today's drought conditions (Stanton and Ackerman 2007). Yet hotter and drier conditions will mean that agricultural and domestic users need more water. That means climate change will

CONTINUED ON PAGE 8

Flooding in Fort Wayne, IN. Higher rainfall in the Midwest and the Northeast owing to climate change will lead to more flash flooding that can damage property and infrastructure.

FIGURE 3.

Projected Drop in Spring Precipitation in the Southwest



Percentage change in end-of-century spring precipitation, compared with the 1961–1979 baseline. Lower water levels in the Southwest will create water shortages, impair hydropower generation, lower tourism revenues, and cause water to be more expensive for businesses, farmers, and households alike.

Source: Adapted from Karl, Melillo, and Peterson 2009.

The Impacts of Climate Change across the United States

Flooding: Under climate change, areas around rivers, lakes, and coastlines are more vulnerable to flooding, which can damage real estate, infrastructure, and crops.

Hurricane intensity: These areas are subject to more intense hurricanes, causing property damage and loss of life.

Beach tourism: Changing water levels and eroding beaches threaten jobs and require costly adaptive measures such as sand replenishment.

Public health: Hotter days and rising ozone levels threaten public health, particularly among at-risk populations such as children and the elderly.

Water scarcity: Changing weather patterns reduce water supplies, increasing the cost for farmers, businesses, and households. Water scarcity also limits the effectiveness of hydropower and the cooling systems needed for nuclear, coal-, and natural-gas-fired power plants.

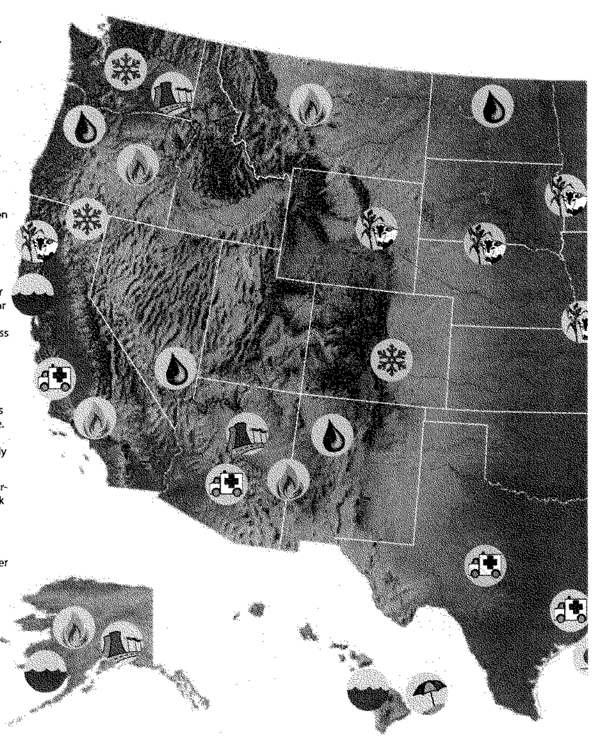
Shipping: Lower water levels make shipping routes on rivers and the Great Lakes less viable. Both farmers and industries depend on those routes to transport goods relatively cheaply.

Winter tourism: Rising temperatures and declining snowpack shorten the skiing and snowmobiling season and require ski operators to make more snow.

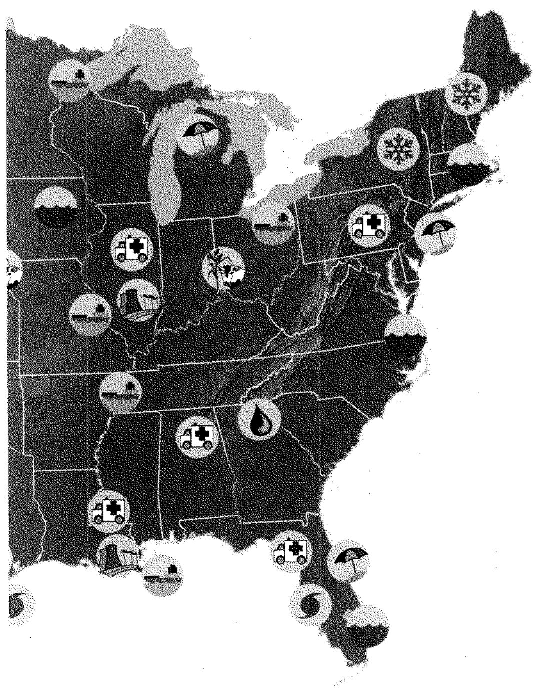
Agriculture: Changing weather patterns, lower water levels along shipping routes, and flooding all threaten to make farming more costly and risky.

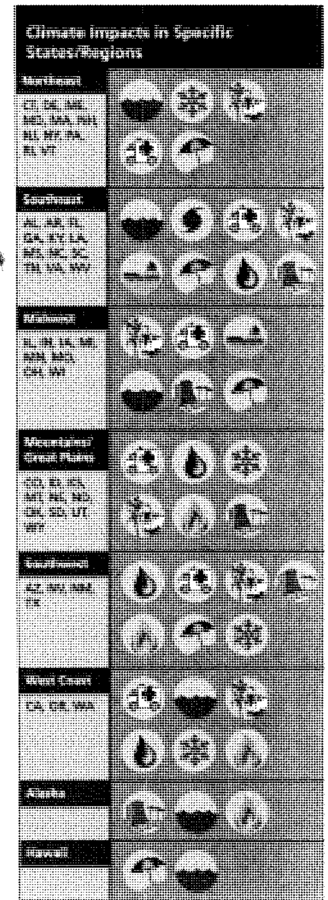
Energy and infrastructure stress: Changing climate patterns threaten our transportation and energy infrastructure.

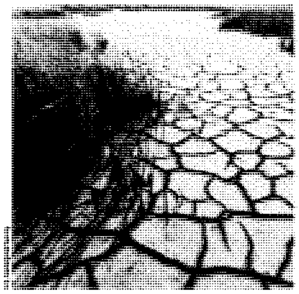
Wildfires: Changing weather patterns will bring more frequent wildfires.



If global warming emissions continue to rise unabated, we will see growing costs related to climate change. This map shows some of the projected damages—to our coasts, our health, our energy and water resources, our agriculture, our transportation infrastructure, and our recreational resources—that will occur in states and regions throughout the United States. Making the choice to dramatically lower our emissions at least 80 percent from 2005 levels by 2050 will help avoid some of the worst consequences of climate change.







Water scarcity, already a problem in many parts of the Southwest, will worsen under climate change, and irrigation costs will skyrocket.

Projected increases in rainfall and runoff in the spring, followed by a drier growing season and more rain during harvest times, will be especially challenging for midwestern farmers.

threaten the survival of irrigated winter agriculture in the region.

Higher temperatures, changes in water levels, and changes in precipitation will also undermine water quality in streams, lakes, and reservoirs, with rising numbers of waterways considered by the U.S. Environmental Protection Agency to be "impaired" by pollution. Sustaining drinking water supplies, wastewater treatment, and storm-water management will require higher expenditures on infrastructure (USEPA 2008).

Impacts on Agriculture

The impact of climate change on agriculture is both complex and uncertain. Higher levels of carbon dioxide will benefit some crops. However, other crops—such as corn, sorghum, and sugar cane—already use carbon dioxide so efficiently that higher levels are unlikely to help.

Higher temperatures will mean higher crop yields in some northern areas. For example, the fruit-growing season around the Great Lakes may be longer (Field et al. 2007). However, in other parts of the country, the effects of climate change on agriculture will be predominantly negative, especially if farmers try to grow the same crops in the same manner as before. While farmers can try to adapt by changing crop types, planting dates, and irrigation and fertilizer practices, such changes will likely come at a cost.

In the Midwest, climate change is already contributing to wetter springs, which can delay the planting of crops. Hot, dry summers will stress crops and reduce yields, while warmer winters mean that crop pests and pathogens normally kept in check by cold temperatures are projected to expand their ranges northward, causing crop damages beyond the $78.5 billion already lost to such pests each year. One study projected a 7 percent increase in precipitation in Illinois, which was expected to increase soil erosion by 19–38 percent, making agricultural production more expensive. When combined with a 4.5°F increase in annual temperatures, the yearly costs of climate change for the state's agricultural sector could reach $9.3 billion (Karetnikov et al. 2008b).

In California, annual losses to agriculture, forestry, and fisheries could reach $4.3 billion under a high-emissions scenario. Hotter conditions will slow production and reduce the quality of many of the state's agricultural products. For example, milk production is expected to fall 22 percent by 2100 under a high-emissions scenario (Kahrl and Roland-Holst 2008). Cooling systems will be expensive but essential to enable livestock farmers to compensate for higher summer temperatures.

Lower rainfall during the growing season threatens the vital agricultural sector in Great Plains states such as the Dakotas. The 2006 drought cost North Dakota's livestock industry $32 million, primarily because of higher feed prices, while crop damage cost farmers $425 million (Karetnikov et al. 2008d).

The lack of a long winter chill in Massachusetts and New Jersey—which now supply nearly half the nation's cranberry crop—will likely mean that those states can no longer produce cranberries by the middle of the century under a high-emissions scenario (Frumhoff et al. 2007; Wolfe et al. 2007).

One study found that the average value of farmland in the rain-fed, non-irrigated areas of the eastern and central United States would fall 25 percent by mid-century, and 69 percent by the end of the century, under a high-emissions scenario. Almost all of that loss would stem from the rising number of days above 93°F, when most crops start to suffer (Schlenker et al. 2006).

Impacts on Transportation

Because they will inundate roads, railroads, airports, seaports, and pipelines, rising sea levels and more severe storm surges could cost commercial transportation hundreds of billions of dollars annually (Karl, Melillo, and Peterson 2009).

Roads and rail. Some 60,000 miles of coastal highway already experience periodic flooding from coastal storms, including high waves (NRC 2008). Global warming will likely worsen such flooding. More intense rainstorms also mean that flooding rivers could wash out or degrade railroad beds and roads.

Longer periods of extreme heat could also damage roads in several ways, such as by softening asphalt, which occurs with sustained temperatures above 90°F. Extreme heat can also cause deformities in railroad tracks, requiring trains to run at slower speeds and even causing derailments, and temperatures above 100°F can lead to equipment failure.

Extreme heat also causes bridge joints to expand, stressing the structures and increasing maintenance costs, as well as adversely affecting bridge operations during such maintenance.

Air travel. Flooding at airports in coastal areas will affect air travel, and aircraft will need higher takeoff speeds and longer runways to obtain the extra lift required at higher temperatures. Recent hot summers have forced companies to cancel flights, especially at high-altitude locations. One analysis projects a 17 percent reduction in the freight-carrying capacity of a Boeing 747 at the Denver airport by 2030, and a 9 percent reduction for such an aircraft at the Phoenix airport, because of higher temperatures and more water vapor (NRC 2008).

Water. Some 200 million tons of bulk commodities, including iron ore and coal, move through Great Lakes ports such as Duluth-Superior each year (Lindeberg and Albercook 2004). This activity supports more than 30,000 U.S. and Canadian jobs, and provides income totaling more than $3 billion per year. For example, Ohio's ports on Lake Erie handle 55 million tons of cargo annually, including iron ore from Minnesota and Michigan, coal from Ohio and nearby states, and numerous other goods (LCA n.d.). The ships are designed and loaded to just barely clear the shallowest points along their routes. Every lost inch of water depth can mean that freighters must reduce their cargo by 50 to 270 tons (Lydersen 2008).

The Midwest also relies heavily on shipping on the Mississippi River and its tributaries, which transport almost 500 million tons of cargo—including coal, petroleum products, farm products, and other bulk materials—every year (USACE 2006). Without access to barge transportation on the upper Mississippi (above St. Louis) and the Illinois River, producers of corn, soybean, and wheat would see their revenues drop by $350 million per year, with Iowa ($152 million), Minnesota ($78 millinn), and Illinois ($50 million) seeing the heaviest losses (FAPRI 2004).

Both too much and too little water can make river navigation more difficult. Low water conditions mean that barges must carry smaller, less profitable loads, or cannot operate at all. Given those conditions, dredging costing $85 million–$142 million annually may be the only way to keep these routes viable (Ruth, Coehlo, and Karetnikov 2007).

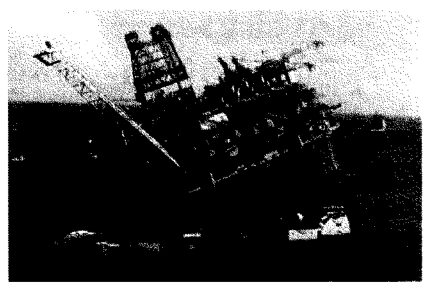
Alaska has warmed more than twice as fast as the rest of the nation over the last 50 years, and the thawing permafrost has damaged roads, runways, water and sewer systems, and other infrastructure. Continued thawing will add $3.6 billion–$6.1 billion to the cost of publicly owned infrastructure by 2030, and $5.6 billion–$7.6 billion by 2080 (Larsen et al. 2008).

Impacts on Energy Infrastructure

Oil and gas infrastructure. Sea-level rise and more severe hurricanes stemming from global warming could cause

Changing water levels in the Great Lakes will lead to economic losses for farmers and industrialists who rely on shipping as an inexpensive way to move crops and other cargo.

Michigan Travel Bureau



Thunder Horse, an offshore oil platform, damaged in 2005 as a result of Hurricane Dennis. Hurricanes often damage oil and gas infrastructure in the Gulf Coast region, creating gasoline shortages and higher gas prices, particularly in the South.

U.S. Coast Guard

huge disruptions along the Gulf Coast, home to 30 percent of the nation's crude oil production and 20 percent of its natural gas production. Such disruptions could also occur in the nearby coastal plains (home to one-third of the nation's refining and processing facilities) and the Gulf of Mexico, which hosts offshore drilling platforms, refineries, and pipelines. Aon Corp., the world's second largest insurance broker, and Willis Group Holdings, the third largest, separately estimated damage to oil and gas producers, drillers, pipeline operators, and

More frequent wildfires could represent one of the most costly impacts of climate change in the Rocky Mountain and West Coast regions.

refiners from two recent hurricanes—Katrina and Rita—at $15 billion (Kennett 2006).

Oil and gas operations in Alaska are also vulnerable to the effects of global warming. Much of the Trans-Alaska Pipeline is built on permafrost, and thawing of the ground beneath the pipeline creates structural instability that could lead to spills and expensive repairs (Ruth, Coelho, and Karetnikov 2007). The number of days in which the tundra is firm enough to allow the transport and operation of drilling and exploration equipment has already dropped from 200 to 100 during the last 30 years (Hinzman et al. 2005; ACIA 2004).

Electricity supply. Water shortages are projected to constrain electricity production in Arizona, Utah, Texas, Louisiana, Georgia, Alabama, Florida, California, Oregon, and Washington state by 2025 (Bull et al. 2007). Washington and Oregon will together lose $1.7 billion in annual revenues from hydropower by 2080 because of declining snowpack and water shortages. Even if the most severe climate change does not occur, analysts project that California could lose 10–20 percent of its hydropower at a cost of $440 million–$880 million annually (Franco and Sanstad 2006).

Rising energy demand. Air conditioning is critical to preventing heat-related illness, yet heat waves can stress and disrupt the electricity supply, as consumers require more power just when demand is highest. For example, during Chicago's 1995 heat wave, a surge in electricity demand led to power outages, depriving even those who had air conditioners of relief. Government, utilities, and power producers can invest in energy efficiency, better energy planning, and new power plants. However, any generating capacity built to avoid power outages on the hottest days typically sits idle for the rest of the year, making it an expensive addition to the electricity system.

In California, analysts expect energy demand to rise 3–20 percent by the end of the century, primarily because of greater use of air conditioning. The added cost in energy bills could total $1 billion–$8 billion each year in today's dollars (Franco and Sanstad 2006).

Rising temperatures also make power generation and transmission systems function less efficiently. One analysis projects that inefficient energy transmission during heat waves will cost New Mexico consumers $1 billion per year by 2080, and that the added cost of air conditioning will cost them $1.6 billion (Niemi 2009a).

In Florida, the annual cost to generate power for extra air conditioning under a high-emissions scenario is projected to be $19 billion in 2100. Temperature increases will also make power generation and transmission systems function less efficiently; partly as a result, every additional degree Fahrenheit of warming could cost Florida consumers $3 billion in electricity costs per year by 2100 (Stanton and Ackerman 2007).

Impacts on Recreational Resources

Rising temperatures and precipitation changes threaten the skiing and snowmobiling industries. Ski areas will require far more snowmaking to remain viable, and in many cases—especially in the highest-emissions scenarios—the ski season may become too short for snowmaking to be profitable, and resorts will close. Snowmobiling, the nation's largest

A warming climate threatens recreational activities such as skiing, snowmobiling, and ice angling, which represent billions of dollars in tourism revenues and thousands of jobs across the country.

winter recreation industry, will see its season shrink 80 percent by 2100 under those scenarios (Frumhoff et al. 2007).

Sea-level rise and other climate changes threaten beach-related tourism. For example, rising ocean temperatures and acidity levels cause coral bleaching and disease, harming the many marine species that depend on coral ecosystems, and thus tourism.

West. Climate change under a high-emissions scenario could spur an 80 percent loss of Sierra snowpack by the end of the century. California's ski season would disappear, and with it 15,000 jobs and $500 million in annual industry revenues. California's tourism assets at risk total $98 billion, while annual losses to tourism revenues could reach $7.5 billion. Reduced snowfall will also harm the ski industry in Washington and Oregon, at an annual cost of $525 million by 2080. Those states could further see a $1.1 billion-per-year decline in their cold-water angling industries by 2080 (Niemi 2009b; Niemi 2009c).

Northeast. Tourism revenues throughout the Northeast are closely tied to maple sugaring, fall foliage, winter sports, hunting, beaches, and many other activities that rely on today's climate. Under high-emissions scenarios, the Northeast stands to lose $5.3 million–$12.1 million per year from maple sugar losses alone. Vermont's sugar maples and other important fall foliage trees will rapidly lose their U.S. habitat under high-emissions, high-temperature scenarios. The region also stands to lose $405 million–$810 million in annual skiing revenues (Ruth, Coelho, and Karetnikov 2007).

Midwest. The Midwest tourism industry stands to lose revenue as water levels in the Great Lakes fall by several feet, curbing water and wetland-based recreational activities such as pleasure boating, fishing, and bird-watching. Rising temperatures in rivers and streams in Michigan and other states will likely reduce sportfishing for trout and other cold-water species (Karetnikov et al. 2008c; Easterling and Karl 2001).

John McColgan/Bureau of Land Management/Alaska Fire Service

Wildfire in the Bitterroot National Forest, MT. Wildfires are expected to become more frequent in the Rocky Mountain and West Coast regions, adding to firefighting costs, property damage, and lost timber.

Southwest. Revenue from activities in the Southwest such as boating, kayaking, and skiing will likely drop because of falling water levels and rising temperatures. For example, the 5.4 percent drop in water level at Lake Powell from 1999 to 2003 cut the number of visitors to the Glen Canyon National Recreation Area by half a million in 2003. The result was a loss of $32.1 million in visitor spending, 758 jobs, and $13.4 million in personal income (Ponnaluru 2005).

If we act quickly and decisively, we can avoid the worst of the costs associated with global warming.

Southeast and Hawaii. With severe beach erosion, flooding of the Everglades, and coral bleaching under a high-emissions scenario, Florida's tourism industry will lose $178 billion annually by 2100. In North Carolina, a sea-level rise of 18 inches by 2080 is expected to cost the beach recreation industry $11 billion in cumulative damages (Karetnikov et al. 2008a). And in Georgia, a sea-level rise of 20 inches could require $1.3 billion in sand replenishment costs by 2100, and lead to a loss of 5,000 jobs in the tourism industry (Horin et al. 2008). Meanwhile, in Hawaii, coral bleaching and sea-level rise threaten that state's $800 million-per-year marine tourism industry (Cesar et al. 2002).

Wildfires

More frequent wildfires could represent one of the most costly impacts of climate change in the Rocky Mountain and West Coast regions. For example, under a high-emissions scenario, Washington will face added annual costs of $380 million by 2080 for property damage from wildfires, and Oregon $497 million (Niemi 2009b). New Mexico stands to lose $2.2 billion annually in lost timber value and additional fire control expenditures by 2080 (Niemi 2009a).

Fire suppression costs on federal lands alone totaled $1.9 billion in 2006 and $1.8 billion in 2007 (Blazer et al. 2008). And the federal government spent almost

Peter Beck/CORBIS

$200 million just in California in 2008, including three fires that cost $50 million each (USDA 2009). California is likely to see a 12–53 percent increase in the annual number of large wildfires by 2100 (Kahrl and Roland-Holst 2008), while annual wildfires in Alaska are expected to triple under a moderate-emissions scenario and quadruple under a high-emissions scenario (Balshi et al. 2008).

Estimates show that states pay another 25 percent on top of federal firefighting expenditures, and that damages to real estate and infrastructure impose further costs on governments, insurers, and homeowners (Rasker 2008).

Conclusion

If global warming emissions continue unabated, every region in the country will confront large costs from climate change in the form of damages to infrastructure, diminished public heath, and threats to vital industries employing millions of Americans. No region can expect a costless adaptation to a rapidly changing climate. Indeed, climate change threatens our very way of life and our legacy to future generations.

The minimum costs presented here will likely outweigh the costs of dramatically reducing carbon emissions starting today. And these projected costs of climate change do not include those that are critical but hard to quantify, such as costs stemming from changes to ecosystems and the need to relocate coastal communities.

Fortunately, if we act quickly and decisively, we can avoid the worst of these costs. A recent UCS analysis, *Climate 2030: A National Blueprint for a Clean Energy Economy*, shows that immediate implementation of a comprehensive suite of climate, energy, and transportation policies can dramatically lower U.S. global warming emissions while saving consumers and businesses money. Congress needs to enact strong climate legislation that includes such policies to safeguard our economy, our environment, and our future.

Union of Concerned Scientists

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Union of Concerned Scientists State Impact Analyses

Union of Concerned Scientists has in-depth analysis on 18 states, including the Midwest, Northeast, and California. The impact report for Illinois can be found in the following pages.

Northeast Region
http://www.climatechoices.org/ne/resources_ne/nereport.html
- Pennsylvania
- New Jersey
- Rhode Island
- Connecticut
- Maine
- New Hampshire
- New York
- Vermont
- Massachusetts

Midwest Region
http://www.ucsusa.org/global_warming/science_and_impacts/impacts/climate-change-midwest.html
- Indiana
- Illinois
- Iowa
- Minnesota
- Michigan
- Missouri
- Ohio
- Wisconsin

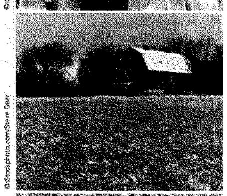
West
http://www.ucsusa.org/global_warming/science_and_impacts/impacts/our-changing-climate.html
- California

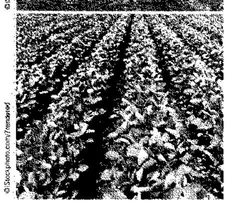
Union of Concerned Scientists

July 2009

Confronting Climate Change in the U.S. Midwest

ILLINOIS



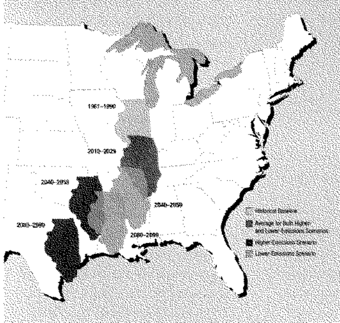


From its fertile farmlands and many riverside communities to its economy, infrastructure, and lifestyle, Illinois has been strongly shaped by its climate. However, that climate is changing due to global warming, and unless we make deep and swift cuts in our heat-trapping emissions, the changes ahead could be dramatic. This report presents new projections showing some of the potential impacts of global warming on Illinois, including severe summer heat, more dangerous storms and floods, and new threats to agricultural production.

GLOBAL WARMING AND THE MIDWEST

Global warming is caused by an increase of pollutants in the atmosphere, including carbon dioxide produced by human activities such as the burning of fossil fuels and the clearing of forests. Carbon dioxide acts like a blanket that traps heat in our atmosphere and warms our climate; oceans, forests, and land can absorb some of this carbon, but not as fast as we are creating it. As a result, heat-trapping emissions are building up in our atmosphere to levels that could produce severe effects including extreme heat, prolonged droughts, intense storms, corrosive ocean acidification, and dangerous sea-level rise.

The climate of the Midwest has already changed measurably over the last half century (De Gaetano 2002; Kunkel et al. 1999). Average annual temperatures have risen, accompanied by a number of major heat waves in the last few years. There have been fewer cold snaps, and ice and snow are melting sooner in the spring and arriving later in the fall. Heavy rains are occurring about twice as frequently as they did a century ago, increasing the risk of flooding.



Illinois' Climate Migrates South

Changes in average summer "heat index"—a measure of how hot it actually feels based on a specific combination of temperature and humidity—could strongly affect Midwesterners' quality of life in the future. For example, the red outlines track what summers in Illinois could feel like over the course of the century under the higher-emissions scenario; the yellow outlines track what summers could feel like under the lower-emissions scenario.

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Effective and Affordable Solutions

The most dangerous effects of climate change are likely to occur if the global average temperature rises more than two degrees Celsius above where it stood in 1850. Science shows we still have a chance of keeping temperatures below this level if we cut heat-trapping emissions deeply and quickly—and limit atmospheric levels of carhon dioxide to 450 parts per million (see *www.ucsusa.org/mwclimate* for more details).

Illinois can do its part by implementing its own carbon-reducing state policies and investing in clean energy technologies that can both reduce consumer energy costs and build new growth industries in the state. Illinois can also play a lead role in calling for strong federal legislation that would provide climate-friendly choices for Illinois consumers and businesses and help for resource managers and local governments that must prepare for the effects of climate change that cannot be avoided.

A recent analysis by the Union of Concerned Scientists (UCS), *Climate 2030: A National Blueprint for a Clean Energy Economy* (Cleetus, Clemmer, and Friedman 2009), demonstrates that the United States can cut heat-trapping emissions deeply and swiftly enough to avoid the most dangerous consequences of climate change. A comprehensive climate and energy approach—combining a cap on emissions with policies that encourage renewable electricity, energy efficiency, and cleaner transportation choices—can reduce emissions 26 percent below 2005 levels by 2020 and 56 percent below 2005 levels by 2030 while saving consumers and businesses money.

Our Analysis

Our analysis considers two different possible futures: one with a lower level of global warming pollution and one with a higher level (see *www.ucsusa.org/mwclimate*). These futures represent the best and worst cases of the emissions scenarios described by the international scientific community in 2000 and which have been used for scientific analysis ever since. However, they by no means encompass the full range of futures that could plausibly unfold.

Climate protection policies, if implemented quickly, could reduce emissions significantly below the lower-emissions scenario considered here. On the other hand, up until 2008, global emissions have been higher than the higher-emissions scenario being considered.

HOW WILL EMISSIONS CHOICES AFFECT ILLINOIS' FUTURE?

Dangerously Hot Summers

Our new analysis projects dramatically hotter summers for Illinois. This is true under both the lower- and higher-emissions scenarios, but the prevalence of extreme heat is much greater under the higher-emissions scenario. The conditions that constitute "extreme" heat were measured in three ways: comparing future summers with the hottest summer during the historical baseline, counting the expected number of days above 90°F and 100°F per summer, and projecting the likelihood of extreme heat waves similar to those that hit Chicago in 1995 and much of Europe in 2003. By all three measures, summers in Illinois will become dangerously hot.

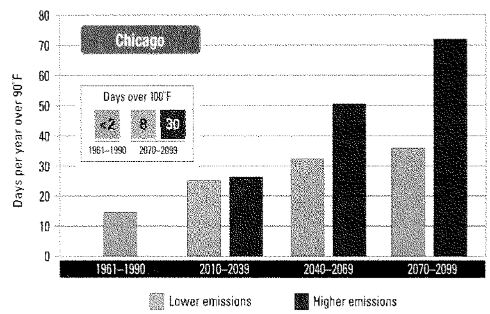
Comparisons with the historical baseline

As soon as the next few decades, almost three-quarters of Illinois' summers could be hotter than the hottest summer the state experienced during the historical baseline (1983, closely followed by 1988). Under the higher-emissions scenario every Illinois summer at mid-century is projected to be hotter than 1983. Even under the lower-emissions scenario 90 percent of summers at mid-century would be hotter than 1983, and all summers would be hotter toward the end of the century (though not as hot as under the higher-emissions scenario).

These findings are particularly troubling because the scorching summers of 1983 and 1988 brought record-breaking heat to Illinois and much of the nation. The average temperature in Illinois in both summers was 3°F higher than normal. The unusual heat of 1988 combined with widespread drought to cause an astonishing $40 billion in losses to agriculture and related industries nationwide—the United States' second costliest weather-related disaster in modern times (after Hurricane Katrina) (Lott et al. 2009). By mid-century, summers like 1983 and 1988 will likely be considered *cooler* than average.

More days over 90°F and 100°F

Because heat waves are especially lethal in cities, where urban landscapes absorb more heat during the day and are less effective at releasing it at night (the "heat island" effect), our analysis focused on the extreme heat projected for the state's largest city, Chicago, and the number of days each year likely to exceed 90°F and 100°F. During the historical baseline Chicago averaged only 15 days per summer with highs over 90°F. That number rises substantially in the next few decades to more than 25 days, and toward the end of the century under the higher-emissions scenario, the city is projected to experience more than 70 days above 90°F—more than two months of the summer. Under the lower-emissions scenario that number would be cut by about half.



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Illinois Could Face Heat Waves of Historic Proportions

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If our heat-trapping emissions continue unabated, heat waves of historic proportions are projected to become routine in Illinois.

[illegible]

As for the more dangerous days over 100°F, Chicago averaged only about two such days each summer during the historical baseline. But toward the end of the century under the higher-emissions scenario, the city is projected to face 30 such days—an entire month. That number would be reduced to eight under the lower-emissions scenario. Compounding matters is the likelihood that Illinois' summers will continue to be humid—probably even more humid. Other Illinois cities such as Peoria, Rockford, and Springfield will face conditions similar to Chicago.

More deadly heat waves

The severe heat projected for Illinois poses serious health risks for residents. Heat waves already kill more people in the United States each year than hurricanes, tornadoes, floods, and lightning combined (CDC 2006), and the average annual death toll of nearly 700 may well be an underestimate, since there are no uniform reporting requirements and many deaths are probably misclassified (Luber and McGeehin 2008). Studies show that deaths from many causes, including cardiovascular and respiratory disease, increase during heat waves.

The health costs associated with heat waves are not limited to deaths; many other people become sick enough to be hospitalized. In 2005, medical costs related to extreme heat and cold totaled $1.5 billion nationwide, or more than $16,000 per patient. The Chicago heat wave of 1995 increased admissions to Cook County hospitals 11 percent (more than 1,000 patients) during the peak week (Semenza et al. 1999). Many heat-related deaths and illnesses can be prevented by improving warning systems, access to air conditioning, and year-round medical staffing.

Our research projects how likely Chicago would be to experience heat waves as severe as those that affected the city in 1995 or Europe in 2003 (see the text box above). Our findings are disturbing; under the higher-emissions scenario, for example:

- By mid-century Chicago would experience a heat wave as hot as the 1995 Chicago heat wave every summer and a heat wave like the 2003 European heat wave at least every fifth summer

- Toward the end of the century Chicago would experience at least two heat waves as hot as the 1995 Chicago heat wave every summer and a heat wave like the 2003 European heat wave every other summer

A heat wave similar to the 2003 European heat wave would cause more than 1,070 deaths in Chicago (37 per every 100,000 residents), compared with 94 heat-related deaths per summer during the baseline period. This assumes the demographics, vulnerability, and infrastructure of Chicago do not change from today. Increased use of air conditioning in the city would likely reduce the death toll, but the general aging of the population would likely increase the death toll since the elderly are most vulnerable to heat. The number of Illinois residents older than 65 is projected to be more than 1.6 times higher in 2030 than 2000, rising to 18 percent of the state's population (U.S. Census Bureau 2004).

Changes in air quality could also play a role: for example, if air quality deteriorates because warmer temperatures exacerbate smog and soot pollution, and we continue to burn more fossil fuels in our power plants and vehicles, heat-related mortality would likely rise. Conversely, cleaner air created by a shift away from fossil fuels would likely reduce heat-related mortality.

More dangerous air pollution

In areas where there are local sources of fossil fuel emissions, ground-level ozone—a dangerous air pollutant and the main component of smog—increases at temperatures over 90°F (Luber and McGeehin 2008). Since our projections show that, under the higher-emissions scenario, Illinois will experience such temperatures virtually the entire summer toward the end of the century, the state can also expect far more days of unhealthy ozone levels than would occur without global warming. This is particularly bad news for the 12 Illinois counties (including those around Chicago and St. Louis, MO) that already experience ozone levels higher than the Environmental Protection Agency's (EPA's) health-based ozone standard (EPA 2008b).

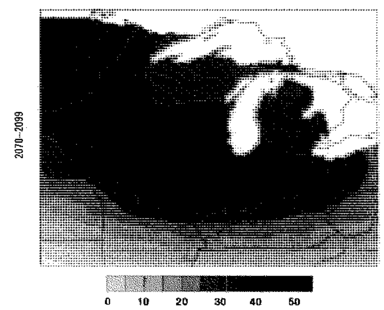
High concentrations of ground-level ozone (not to be confused with ozone in the stratosphere, which provides an important natural shield against solar radiation) diminish lung function, cause a burning sensation in the lungs, and aggravate asthma and other respiratory conditions. Ozone may also contribute to premature death, especially in people with heart and lung disease (EPA 2008). Studies show that when ozone levels go up, so do hospitalizations for asthma and other lung conditions, and it appears that heat and ozone together increase mortality (Luber and McGeehin 2008). Ozone also damages plant life; the EPA warns that a climate change-induced increase in ozone could damage ecosystems and agriculture as well as human health (EPA 2008).

Another air contaminant of particular concern in Illinois is small particulate pollution (or soot); the 12 counties mentioned above have already been identified as failing to meet federal air quality standards for this pollutant (EPA 2004), and Chicago ranks among the nation's 10 most soot-polluted cities (ALA 2009). Small particulates increase the severity of asthma attacks in children, increase the number of heart attacks and hospitalizations related to cardiovascular disease and asthma, and cause early deaths from heart and lung disease (ALA 2009).

The leading source of small particulate air pollution is coal-fired power plants, and as demand for electricity increases in response to rising temperatures, power plants generate more emissions. Therefore, climate change threatens to exacerbate Illinois' particulate air pollution.

In Illinois today, more than 8 percent of the population (more than 244,000 children and more than 650,000 adults) suffers from asthma (ALA 2009). Heart disease caused 548 of every 100,000 deaths among

Higher-Emissions Future



Percent increase in spring rainfall compared with average from 1961–1990

Spring Rains Increase

Heavy downpours are now twice as frequent in the Midwest as they were a century ago. Under the higher-emissions scenario, Illinois' spring rainfall is projected to increase almost 15 percent over the next several decades and more than 30 percent toward the end of the century. This may lead to more flooding, delays in the planting of spring crops, and declining water quality in rivers, streams, and storage reservoirs.

residents older than 35 between 1996 and 2000 (CDC 2009). The combination of increasing heat, ozone, and small particulate pollution can be especially dangerous for these populations.

Changes in Storm, Flood, and Drought Patterns

In 2008 Illinois experienced a year of devastating storms and flooding, which affected virtually every part of the state between January and September. In June alone, floods caused hundreds of evacuations; breached levees along the Mississippi, Embarras, and Wabash Rivers; and threatened thousands of acres of the state's agricultural land. Twenty-nine counties were declared federal disaster areas and the state received more than $90 million in federal disaster assistance (FEMA 2008).

As heavy rainfalls become more common, the threat of flooding will rise, as will the value of the property at risk and the costs of emergency response systems and flood control measures such as levees and dams.

More frequent downpours and flooding

Heavy downpours are already twice as frequent in the Midwest as they were a century ago (Kunkel et al. 1999). While scientists cannot attribute any single storm to climate change, more heavy precipitation can be attributed to climate change that has already occurred over the past 50 years (Trenberth et al. 2007).

Our analysis indicates that the warming ahead will make Illinois substantially more vulnerable to the kind of natural disasters it suffered in 2008. Two findings stand out from the research:

- **Precipitation is more likely to arrive in the form of heavy rains.** Under the higher-emissions scenario Chicago is projected to experience a more than 20 percent increase in heavy rainfalls (defined as more than two inches of rain in one day) over the next few decades. Toward the end of the century, heavy rainfalls are projected to be 50 percent more frequent under the higher-emissions scenario and 35 percent more frequent under the lower-emissions scenario.
- **Winters, springs, and falls will be wetter but summers will be drier.** Winters and springs are projected to see almost one-third more precipitation toward the end of the century under the higher-emissions scenario, and autumns are projected to see more precipitation as well. Meanwhile, summers will see almost 15 percent less rain. As described above, more of the rain that does fall will be in the form of downpours.

These projections show a substantially increased risk of flooding in Illinois as the century progresses, especially if emissions are high. While there is likely to be some increase in local summertime flooding due to more frequent downpours, the greatest flooding risk will occur in the winter and spring, when seasonal precipitation is expected to increase the most. In fact, analyses of various rivers in the Midwest (which used a level of emissions somewhat lower than our higher-emissions scenario) projected more than triple the number of high-flow days toward the end of the century (Cherkauer and Sinha 2009; Wuebbles et al. 2008).

More frequent short-term droughts

Paradoxically, Illinois could face not only the risk of greater flooding but also the risk of greater drought, although climate projections are less consistent in this regard. The more temperatures rise, the more water evaporates from the soil and plants, requiring more rainfall just to maintain the same soil moisture levels. However, the Midwest is projected to receive less rain in the summer (when temperatures are hottest), not more. As a result, the likelihood of drought in the region will increase, as overall water levels in rivers, streams, and wetlands are likely to decline. In Illinois, short-term droughts are projected to increase, but long-duration droughts (lasting more than two years) are likely to decline.

Lower water levels in the Great Lakes

Water levels in the Great Lakes are projected to decline both in summer (due to increased evaporation caused by higher temperatures) and winter (due to a decrease in lake ice) (Angel and Kunkel 2009; Hayhoe et al. 2009). The greatest declines are expected for Lake Huron and Lake Michigan. Under the lower-emissions scenario, water levels are projected to fall less than one foot toward the end of the century; under the higher-emissions scenario, levels are projected to fall between one and two feet. A decline of this magnitude can have significant economic, aesthetic, recreational, and environmental impacts, such as significantly lengthening the distance to the lakeshore, affecting beach and coastal ecosystems, exposing toxic contaminants, and impairing recreational boating and commercial shipping.

More threats to water quality

Heavy rains increase runoff that not only washes pollutants into waterways but—in cities such as Chicago—also causes raw sewage to spill from sewers into rivers and lakes. In the Chicago region, a mix of storm water and untreated sewage flows into Lake Michigan when more than about two inches of rain falls in one day (Lanyon 2007). Heavier downpours ahead mean the typical overflows of years past are likely to be exceeded.

To deal with this excess runoff, the city of Chicago is currently adding reservoirs to the existing network of sewage tunnels 200 feet below the Chicago River system. These reservoirs, which will be completed in phases over the next 10 years, will hold excess storm water and should reduce the occurrence of overflows (DWM 2009). Other cities may also need adaptation plans and new infrastructure to cope with the projected changes in rainfall.

New Threats to Illinois' Agriculture

Illinois is an important part of the nation's agricultural heartland. Nearly 67 percent of the state's acreage is devoted to cropland (USDA 2009a); it ranks second nationally in total crop value, second in acres devoted to corn and soybeans, and first in grain, oilseed, dry bean, and dry pea sales. Illinois also boasts one of the nation's most productive livestock industries, ranking fourth in hog and pig sales (USDA 2009b). In 2002, nearly 13 percent of Illinois' jobs were farm-related (USDA 2005) and, in 2007, agricultural commodities brought more than $11 billion to the state (USDA 2009a).

The heat and precipitation changes projected for Illinois have potentially profound implications for agricultural production. Toward the

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Changes Mean Uncertainty for Agriculture

Farmers in Illinois would benefit from the longer growing seasons expected to accompany global warming, but projected increases in spring rains could interfere with planting and cause more flooding. Farmers therefore face greater risk and expense if climate change continues unabated.

Livestock Face Increasing Heat Stress

If heat-trapping emissions continue to rise at their current pace, the state's dairy cattle, hogs, pigs, and other livestock may experience [illegible] and heat stress during the average summer toward the end of the century. Adaptation options include costly measures such as air-conditioned barns and spraying livestock with water during the hottest periods.

end of the century, growing seasons are likely to lengthen by three weeks under the lower-emissions scenario and by six to seven weeks under the higher-emissions scenario. Also, rising CO_2 levels have a fertilizing effect on crops. These changes by themselves would increase crop production, but they will be accompanied by many other changes that threaten production, such as heat stress, increased drought and flood risks, and an expansion of crop pests' range.

More heat stress for crops

The extreme summer heat projected for Illinois, particularly under the higher-emissions scenario, puts the region's crops at significant risk. Corn crops, for example, can fail at 95°F, with the risk increasing the longer the heat lasts. When such hot spells coincide with droughts, as they often do, crop losses can he severe.

The United States lost $40 billion from a 1988 heat wave—mostly due to crop losses. Crop yields in Illinois dropped precipitously that year, with corn and soybeans falling well below three-quarters of their average annual yields for the period 1978–1997 (USDA 2009c). Over the next few decades (under both emissions scenarios) most Illinois summers are projected to be hotter than 1988, and by mid-century under the higher-emissions scenario, all Illinois summers are projected to be hotter than 1988.

Our analysis projects the frequency with which Illinois and the Midwest would face three- and seven-day periods of crop-damaging temperatures of 95°F or higher. During the historical baseline such periods of intense heat were extremely rare in the Midwest, with three-day periods occurring about once every 10 years and seven-day periods occurring on average only once every 30 years in the more southern states.

Under the higher-emissions scenario, however, a three-day period with temperatures reaching 95°F or higher is projected to occur at least every other summer in Illinois within the next few decades, and every summer toward the end of the century. A more destructive seven-day period would occur every other summer by mid-century and in at least three of every four summers toward the end of the century. Under the lower-emissions scenario, the frequency of such periods would be significantly less toward the end of the century, with a week-long period of extreme heat occurring in less than half of Illinois' summers.

The possibility of crop-damaging heat waves becoming commonplace in Illinois within a few decades represents a significant threat to the state's economy, which took in nearly $5.7 billion from corn alone in 2007 (USDA 2009a). Crops such as wheat that fail at lower temperatures than corn are even more vulnerable.

A detailed study of the expected effects of climate change on crop yields in five Midwest states shows that corn yields in Illinois may decline as much as 50 percent by the middle of this century under a variety of scenarios and assumptions (Southworth et al. 2000). For soybeans, a crop that benefits more than corn from CO_2 fertilization, results were mixed, with some scenarios showing small yield gains and others showing decreases. In neighboring Indiana, the study's two locations had differing results for wheat, with yields declining as much as 15 percent in southwestern Indiana but increasing by small amounts in east-central Indiana.

Hotter projected temperatures led to lower yields in all cases; corn yields, for example, begin to decline at 92°F and fall sharply at 100°F. Widely varying climate conditions during the growing season also decreased average yields in all of the study's models, so as temperatures continue to rise and weather becomes more extreme and variable, yields of all major crops will likely decline.

More heat stress for livestock

Extreme heat is also projected to cause heat stress for much of Illinois' livestock. Dairy cattle are particularly vulnerable to high temperatures, and milk production can decline when temperatures exceed 75°F to 80°F depending on humidity. Hogs, whose sale brought more than $800 million to Illinois in 2007 (USDA 2009a), begin to feel heat stress when the heat index (a combined measure of temperature and humidity) surpasses 72°F. Illinois already loses $20.5 million each year due to heat stress in swine (St.-Pierre, Cobanov, and Schnitkey 2003), and under the higher-emissions scenario, near-permanent heat stress will affect dairy cattle, hogs, pigs, and other livestock during the average Illinois summer toward the end of the century—unless they are kept cool using costly measures such as air-conditioned barns.

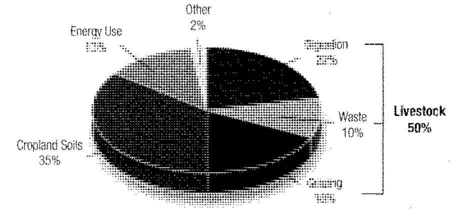
Wider spread of pests

The warmer winters ahead mean that crop pests and pathogens normally kept in check by cold temperatures are projected to expand their ranges northward. A recent study warned that the expanding ranges of corn pests could have a substantial economic impact in the form of higher seed and insecticide costs and lower yields (Diffenbaugh et al. 2008). Already, corn pests cost U.S. corn producers more than $1 billion annually; the corn earworm alone is responsible for destroying about 2 percent of the nation's corn crop every year, and it has shown resistance to a wide range of insecticides (Diffenbaugh et al. 2008).

Illinois' valuable corn crop would be at risk if the corn earworm does indeed move north. During the historical baseline, conditions conducive to the corn earworm occurred about once every 15 years in central Illinois and once every three years in parts of southern Illinois. Under the higher-emissions scenario, however, conditions conducive to the corn earworm would occur in about half of all years toward the end of the century in central Illinois, and almost every year in southern Illinois.

Potentially damaging changes in precipitation

Crops under stress from extreme heat need more rain, but Illinois is projected to receive less rain in the summer growing season as the climate warms. Dry conditions will be a particular problem for Illinois' crops because only about 2 percent have access to irrigation (USDA 2009a). In addition, the projected increase in spring rains could interfere with planting and pose a greater risk of floods like those of June 2008, which affected thousands of acres of Illinois farmland (MRCC 2009). Changes in precipitation are therefore likely to limit farmers' ability to take advantage of the longer growing seasons expected to accompany future climate change.



Emissions percentages are CO_2-equivalent units

Agriculture Contributes to Warmer Temperatures

Agriculture generates 7 percent of total U.S. heat-trapping emissions, including three potent global warming gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Half of these emissions come from livestock production, one-third from the cultivation and fertilization of cropland (which decreases its ability to absorb carbon), and the rest from energy used for power generation, transportation, and construction (USDA 2008).

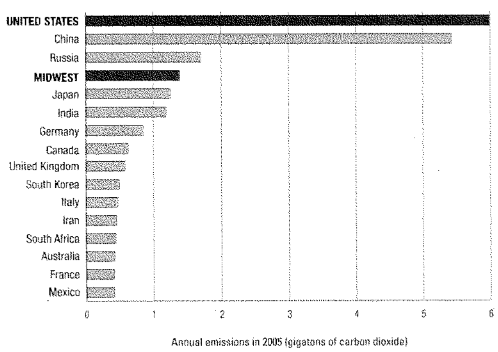
CLIMATE SOLUTIONS FOR ILLINOIS

Illinois is the sixth largest producer of global warming emissions among all the states (EIA 2008a). Energy use, largely in the form of electricity generation and transportation, accounts for 85 percent of the state's emissions.

These emissions would be significantly lower if electricity generation in Illinois had not increased by 50 percent—almost double the national growth rate—since 1990, primarily as a result of deregulation. Illinois now generates about 30 percent more electricity than it uses, exporting the excess to other states (ICCAG 2009). Less than 1 percent of this electricity comes from clean, renewable resources such as hydro, solar, and wind power; 48 percent comes from risky nuclear power and the rest from dirty fossil fuels: 47 percent coal and 3 percent natural gas (EIA 2009b).

If Illinois and the world are to avoid the worst consequences of climate change, the state must aggressively reduce its emissions by:

- increasing energy efficiency and conservation in industries and homes;
- boosting the use of renewable energy resources such as wind power, advanced biofuels, and geothermal energy;
- improving vehicle fuel efficiency and reducing the number of miles driven; and
- improving agricultural practices to reduce the release of heat-trapping emissions from soil tilling and fertilizer application.



The Midwest Burns More Fossil Fuels Than Entire Nations

The total combined emissions from eight states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin) would make the Midwest the world's fourth largest polluter if it were a nation. The region's emissions are more than double those of the United Kingdom, which has about the same population (EIA 2008a).

These actions will also provide benefits such as lower energy costs (after just a few years), new local jobs, and cleaner air and water. A recent analysis by the Union of Concerned Scientists shows that businesses and industries in the Midwest could collectively save $3.8 billion on their electricity bills in 2020 and $11.9 billion in 2030 by instituting these kinds of changes (Cleetus, Clemmer, and Friedman 2009).

Illinois has made strides toward implementing a number of the strategies listed above and deserves credit for its progress on the following initiatives:

- One of the strongest renewable energy standards in the nation, requiring utilities to supply customers with 25 percent renewable electricity by 2025.
- A requirement that electric and natural gas utilities reduce energy demand through energy efficiency programs. Illinois is one of only four Midwest states with such a policy, which can save consumers money, reduce global warming emissions, and create local jobs for people who perform energy audits, weatherize homes, and manufacture efficient windows.
- Building codes that will require new construction statewide to meet the regularly updated standards of the International Energy Conservation Code (IECC). Homes built to the 2009 IECC standards could save Illinois homeowners between $300 and $650 in annual energy costs (MEEA 2009).

Pathways to Real Progress

Illinois can do much more to take advantage of clean energy opportunities and reduce global warming emissions, by pursuing the cost-effective strategies summarized below.

Stop investing in polluting coal plants

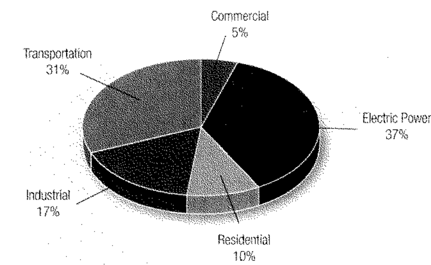
Illinois should adopt a moratorium on both the construction of new coal-fired power plants and the import of power from new coal plants outside the state—unless and until such plants adopt carbon capture and storage (CCS) technology (provided this proves commercially feasible). New financial commitments to coal plants without CCS will lock the state into high emissions for decades, while inhibiting needed investments in clean energy technologies.

Promote combined heat and power

The Illinois Climate Change Advisory Group recommended greater use of combined heat and power (CHP), which uses waste heat from industrial processes to generate electricity. Illinois should encourage the technology's expansion through tax incentives, attractive financing arrangements, and favorable utility rate structures.

Stabilize and expand public transit and high-speed rail

Only California and New York boast more public-transit ridership than Illinois (BTS 2001), and the numbers can be expected to grow due to rising gasoline prices, clogged highways, and the economic recession. Unfortunately, because the Chicago Transit Authority (CTA) is chronically under-funded, its trains are in poor condition, routes are being cut, and fares increased—all of which can put people back on the roads and add to Illinois' global warming emissions.



Vehicles and Power Plants Are Illinois' Biggest Polluters

Transportation and electricity generation—primarily from coal-fired power plants—are the largest sources of heat-trapping emissions in Illinois (EIA 2008). This chart reflects CO_2 emitted by power plants within the state; it has not been adjusted to reflect power imported to or exported from Illinois.

The state needs to correct these problems and make a new investment in clean, efficient transit.

In addition, a high-speed rail network throughout the region would offer a low-carbon alternative to driving and flying, but after years of discussion, little progress has been made. Illinois and other midwestern states should aggressively pursue federal stimulus dollars and other funding for this project.

Building More Resilient Communities

Because climate change is already upon us and some amount of additional warming is inevitable, Illinois must adapt to higher temperatures and more heavy rains while working to reduce its emissions. Any delay in emissions reductions will make it more difficult and costly to adapt; conversely, aggressive steps to reduce emissions *now* will provide the time ecosystems and societies need to become more resilient. For each adaptation measure considered, Illinois' decision makers must carefully assess the potential barriers, costs, and unintended social and environmental consequences.

A State-Federal Partnership

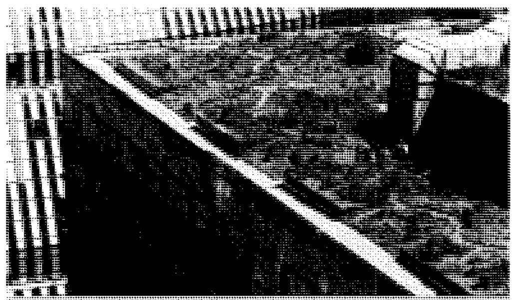
Although Illinois can achieve much with its own policies and resources, the scale of emissions reductions required suggests that individual states will need strong support from the federal government. The United States should therefore enact a comprehensive set of climate and energy policies including standards for renewable electricity, energy efficiency, and transportation that set a tight limit on heat-trapping emissions nationwide. The goal should be to reduce emissions at least 35 percent below current levels by 2020 and at least 80 percent by 2050.

A national renewable electricity standard and strong fuel economy standards for cars and trucks can boost local economies while substantially reducing emissions nationwide. For example, a renewable electricity standard of 25 percent by 2025 would lower electricity and natural gas bills a total of $3.28 billion by 2030 (UCS 2009). A separate UCS analysis showed that if every car and light truck on U.S. roads averaged 35 miles per gallon (mpg) by 2018 (compared with the fleetwide average of 26 mpg today), drivers would save enough in fuel costs to create 10,300 new jobs in Illinois by 2020 (UCS 2007b). The Obama administration is currently pursuing new standards that would achieve an average of 35.5 mpg by 2016.

Another complementary federal strategy known as a "cap-and-trade" program would set a price on emissions and require polluters to obtain government-issued permits in order to continue emitting. By auctioning these permits the government could generate revenue for investment in:

- Energy efficiency and renewable energy solutions
- Assistance for consumers, workers, and communities facing the most difficult transition to a clean energy economy (coal miners and mining towns, for example)
- Conservation of precious natural resources
- Assistance for communities that must adapt to unavoidable consequences of climate change

Setting a price on heat-trapping emissions will also stimulate investment in cleaner and more efficient energy technologies such as CCS by making them more cost-competitive.



Finally, federal resources devoted to climate monitoring and assessments can provide essential information for states and communities that need to devise and implement adaptation plans. Illinois' U.S. senators and representatives must therefore support strong federal climate and clean energy policies that will help the state reduce emissions, transition to a clean energy economy, and prepare for the climate change that will occur in the interim.

CONCLUSION

Global warming represents an enormous challenge to Illinois' way of life and its residents' livelihoods, but we can meet this challenge if we act swiftly. The emissions choices we make today—in Illinois and throughout the nation—will shape the climate our children and grandchildren inherit. The time to act is now.

Peter Frumhoff (UCS) Responses

Senator Bernard Sanders

1. We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Efficiency Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

Yes, we do agree that this committee should set flexible energy efficiency investment criteria for the LDC allocation. Energy efficiency is the "low-hanging fruit" when it comes to reducing carbon emissions and our energy bills, and investing in energy efficiency should be a top priority. Therefore, we request that the bill includes a provision that requires an investment in energy efficiency equivalent to at least 1/3 of the value of the total allowance allocation given to electrical utilities, similar to the 1/3 efficiency investment in natural gas already present within the bill. This would generate $100 billion in electric efficiency investments, create more than 900,000 new construction and energy services jobs by 2020, and many more additional jobs at plants that supply this sector, and reduce consumers' energy bills by $300 billion.

Senator James M. Inhofe

1. I am concerned, as you are, about water in the US. In the report you submitted for your testimony you mentioned the problems with water consumption and conventional electricity production. Water is also heavily used for renewable energy production, especially in solar fields in the southwest where water is already scarce. This bill establishes a new federal obligation to use "all practical means" to protect fish and wildlife from climate change impacts. How do we balance the adaptation needs of fish and wildlife with other needs for water such as alternative energy, and for human consumption and agriculture?

The most practical means of protecting fish and wildlife from climate change impacts is aggressive, near-term mitigation to stem the impacts and ensure future habitat is available to support these populations. This is the sensible first line of defense. Certain changes in climate, as discussed, are now unavoidable and should be planned for with careful decision-making across sectors -- including energy, water and wildlife. Thermoelectric power plants -- conventional or renewable -- employ various technical options that determine the amount of water they withdraw and consume. Balancing the various demands on our water resources will require understanding those technical options, considering the various demands relative to others, and putting in place the incentives that allow plant developers to make the best choices with regard to energy production and water management. Energy choices that are low-water and low-carbon can help ease the growing pressure on water and wildlife.

We also support the notion that all renewable energy projects must be sited correctly and water impacts are an important siting consideration. Even so, the water use of renewable electricity is much lower in comparison to conventional electricity production like nuclear, coal and petroleum. The UCS Climate 2030 Blueprint (see below) notes that if we embark on a serious carbon-reduction path (cap and trade, a renewable electricity standard, and energy efficiency standards), then there will be 1.2 trillion net gallons of water savings in electricity sector by 2030, which is 3 times the volume of Lake Erie, and the annual water use by 32 million people.

→ Climate 2030: A National Blueprint for a Clean Energy Economy (UCS):
http://www.ucsusa.org/assets/documents/global_warming/climate-2030-report.pdf

2. In the booklet you included with your testimony it says that "there is generally insufficient information at present to evaluation the effectiveness, costs, and benefits of potential climate adaptation actions." Given that we don't know how climate change will affect certain areas, how do you propose funding adaptation programs if we don't know their costs and benefits?

Actually, we have a pretty good idea of how climate change will affect different regions in the United States. The Union of Concerned Scientists has published various regional and state-by-state analyses of the impact of global climate change and adaptation suggestions, such as our Confronting Climate Change in the Midwest report (see below). The National Oceanic and Atmosphere Administration also published a comprehensive report earlier this year detailing the impacts of climate change in the US by region. NOAA's Global Climate Change in the US report concludes that climate changes in the US are already happening and projected to grow, that crops and livestock will be increasingly challenged, and that threats to human health will increase. The interactive feature (link below) illustrates the regional impacts expected from climate change, including the specific issues Oklahoma is expected to face in the short and long term.

So, although we may not have every detail currently worked out for adaptation strategies, it is clear that the magnitude of the risk from climate change is high and the need for adaptation funding is great. As adherents to the scientific precautionary principle, we feel it is essential to act now and develop adaptation programs rather than wait and deal with the expensive consequences of our inaction (please see UCS report Climate Change in the United States: The Prohibitive Costs of Inaction). Many states, such as California, Maryland, Colorado, and others have already begun developing and implementing adaptation programs, and it's time that the Federal government follows suit.

→Confronting Climate Change in the Midwest report (UCS):
www.ucsusa.org/mwclimate
→Global Climate Change in the US report (NOAA):
http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf
→Interactive Regional Impacts (NOAA):
http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts
→Climate Change in the United States: The Prohibitive Costs of Inaction (UCS):
www.ucsusa.org/climatecosts

Senator BOXER. Thank you.

Next we hear from Larry Schweiger, President and Chief Executive Officer of National Wildlife Federation.

Welcome.

STATEMENT OF LARRY J. SCHWEIGER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, NATIONAL WILDLIFE FEDERATION

Mr. SCHWEIGER. Thank you, Senator.

Good afternoon, Madam Chairman and members of the committee. I want to thank you and the other members who have sponsored this important bill and for the work that you are doing to advance this bill of this day.

Thanks also for the opportunity to testify on behalf of the National Wildlife Federation and our over 4 million members and supporters across America.

This bill before us addresses the most compelling challenge of our time. It means more jobs, less pollution, and greater security for every American. It includes sensible provisions to minimize the costs for families in all parts of the country, provides fair distribution of resources to solve our energy needs, and helps vulnerable people in developing countries cope with climate change while protecting nature.

Congress must enact a two-part agenda. It must cap and reduce pollution to levels dictated by science to avoid the most dangerous consequences. And it must provide dedicated funding to address the inevitable impacts of global warming on nature.

The Federation supports the strongest CO_2 targets possible. The 20 percent near-term reduction is a modest, easily achievable target and is the minimum starting point for moving forward on this problem.

The fourth report of the Intergovernmental Panel on Climate Change warns that in the lifetime of a child born today, some 20 to 30 percent of the world's plants and animals will be on the brink of extinction if we do not take bold action now. A million species could be denied to our children and our grandchildren if we allow current carbon emissions to continue, if we fail to safeguard nature from the worst impacts of climate change.

Because of this, we are pleased that the Chairman's mark provides long-term dedicated funding for natural resources. I would like to highlight the work of Senator Baucus and Senator Whitehouse on these provisions particularly. The investments provide essential public and private sector jobs, especially in rural areas where local economies are dependent on natural resource activities.

Our country is blessed with an abundance of natural wealth. It provides food, shelter and economic and spirituality vitality. Unique landscapes define us as Americans. I think Ken Burns in his film recently spelled that out clearly to all of us.

Born and raised as a hunter and angler, I can say that my wildlife heritage has helped me forge family values, and I hope to pass this on to my children. I think that is true of many other American families from generation to generation.

These hearings are about whether Congress and all of America will step up to its moral duty. If we do, one day we will be able to look our children and grandchildren in the eye and be proud of our conservation heritage. If we fail to act now, the alternative is almost unimaginable. It is not an exaggeration to call what we are facing a climate crisis. This will be the defining challenge of the 21st century.

For years, commentators have framed climate change such as melting of Arctic sea ice and rising of seas as mere possible outcomes in the distant future. In fact, these and other profound ecosystem changes and climate feedbacks are well underway and are occurring far more rapidly that scientists recently projected.

I just wrote a book called Last Chance: Preserving Life on Earth which I will provide to the committee and ask that it be included in the record. I believe we are facing our last chance to protect life on earth as we have known it. If we fail to cap pollution, nothing we can do on the adaptation front will save endangered wildlife or conserve ecosystems, including parks, marine sanctuaries, refuges and forests that support the economy and protect our quality of life.

If we cap pollution but fail to make investments in protecting and restoring our natural resources, we will have accomplished only half of the job. Any solution must do both. It must cap pollution and use some of the resources generated to repair the current and future damages caused by global warming.

I must ask. Are we ready to talk about a world without polar bears, without vast sage brush depth and free roaming antelopes? Are we willing to talk about a world without ice fishing or deep snows in the winter, a world with insufficient river flow in the summertime to support salmon and trout, a world where coastal wetlands teeming with wildlife is just a memory?

The choice is ours. The time is now.

The National Wildlife Foundation and our partners are committed to doing all that we can to safeguard nature from a warming world. We are working with scientists, resource managers and a coalition of over 700 hunting and fishing and conservation organizations from every State in the Union. Just the other night, we had over 13,000 sportsmen on the phone with Senator Warner talking about this very issue.

This bill offers America a better way to power our future and to protect our planet. America has always worked best when we work together. Let us work together not to meet our moral obligations to future generations.

Thank you.

[The referenced book was not received at time of print.]

[The prepared statement of Mr. Schweiger follows:]

Testimony of
LARRY J. SCHWEIGER, PRESIDENT and CEO
NATIONAL WILDLIFE FEDERATION

Before the
SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

OCTOBER 28, 2009

NATIONAL
WILDLIFE
FEDERATION

I. INTRODUCTION

Good morning, Chairman Boxer and members of the Committee, my name is Larry Schweiger and I serve as President and CEO of the National Wildlife Federation. I would like to thank you for the opportunity to testify today on behalf of our more than four million members and supporters.

I would like to begin by thanking you, Madam Chairman, as well as Senator Kerr and other key leaders, for the Clean Energy Jobs and American Power Act (S. 1733) and its comprehensive approach to protecting our fragile planet, the American economy, and American jobs in the face of climate change. I also would like to thank Senators Baucus and Whitehouse for the careful attention they have given to the natural resources adaptation provisions of this bill. The National Wildlife Federation and its conservation partners are pleased that S. 1733 provides long-term dedicated funding, using pollution allowances, for a strategic approach to natural resources adaptation. These investments will be a boon to the economy and will provide crucial public and private sector jobs, especially in rural areas of the country where local economies depend heavily on a healthy natural resources base. We look forward to helping you build bipartisan support for enacting a strong final product in the coming weeks.

The American people deserve nothing less. Our nation is blessed with an abundance of natural resources that are essential for our food, shelter and economic vitality. They provide for our physical and spiritual well being. Our unique habitats and landscapes define us as Americans. Born and raised as a hunter and an angler, I can say that our unique wildlife heritage has helped forge many of my family's traditions and values as well as those of many other American families from generation to generation.

Since the conservation leadership of President Theodore Roosevelt, millions of Americans have devoted themselves to protecting and restoring our country's natural resources. We have all benefited from their work in countless ways. Now, because of unchecked global warming, a century of conservation achievements is in jeopardy.

As you conduct your work on this most compelling challenge of our time – protecting our children's and grandchildren's inheritance from global warming - let us remember the words of President Roosevelt:

"Of all the questions which can come before this nation, short of the actual preservation of its existence in a great war, there is none which compares in importance with the great central task of leaving this land even a better land for our descendants than it is for us ...,

Conservation is a great moral issue, for it involves the patriotic duty of insuring the safety and continuance of the nation. Let me add that the health and vitality of our people *are at least as well worth conserving as their forests, waters, lands, and minerals, and in this great work the national government must bear [a] most important part."*

Today's hearing is essentially about whether Congress will step up to its moral duty to ensure our children and grandchildren are not left with a world fundamentally different than the one we have enjoyed. Are we ready to tell them that much of what we have enjoyed on earth will not be available to them?

I ask you, Madam Chairman, and Committee members: Are you ready to talk about a world that no longer has polar bears? Vast sagebrush steppe with free-roaming antelope? Ice fishing or deep snows in the winter? Sufficient river-flows in the summer for salmon and trout? Coastal wetlands teeming with waterfowl?

It is not an exaggeration to call what we are facing a climate crisis. In fact, a key problem with the debate so far has been *understatement.* For too many years, commentators framed climate changes such as melting of Arctic sea ice and rising of the seas as mere possible outcomes in the distant future. In fact, these and other profound ecosystem changes are well underway and are occurring far more rapidly than scientists once projected. With the current pace of climate change, it is hard to imagine what life will look like even ten years from now.

Far too many people remain unaware of the gravity of the climate crisis. It is a story we'd rather not hear or face up to. It is a story, however, that we can still alter, if we act swiftly. But the window is rapidly closing. This year I wrote a book entitled *Last Chance: Preserving Life on Earth* because I believe we are facing our last chance to protect life on earth as we have known it. The time for action is now.

National Wildlife Federation and our partners in conservation are extremely pleased that you chose the topic of adaptation for today's fourth panel. We must do all we can now to safeguard natural resources from a warming world. We are working with scientists, resource managers and a coalition of roughly 600 hunting, fishing and conservation organizations from every state in the nation, asking Congress to design climate and energy legislation that will conserve and protect fish, wildlife and natural areas -- including parks, marine sanctuaries, refuges and forests – from the impacts of global warming. (*See* Appendices A and B). We must not wait until the full impacts are upon us. We must prepare responsibly by conserving the resources we need right now, and developing new strategies that integrate climate science into conservation management plans.

If I had a magic wand – and believe me I wish I did – to end all carbon pollution tomorrow, the negative impacts on wildlife and natural resources would continue for decades. Congress must recognize that the climate crisis requires bold action on the effects as well as the causes.

As S. 1733 recognizes, we must invest *now* in safeguarding the natural world from the inevitable impacts of global warming. The fourth report from the Intergovernmental

Panel on Climate Change (IPCC) report warns that in the lifetime of a child born today, **20 to 30 percent of the world's plant and animal species will be on the brink of extinction if we don't take action now.**[1] The legacy of fish, wildlife and plant species that we inherited from our parents -- and have benefitted tremendously from – will be denied to our children and grandchildren if we allow current carbon emissions to continue and if we fail to invest now in adaptation.

Of course, if we fail to cap and reduce the pollution that contributes to global warming, nothing we can do on the adaptation front will save our endangered wildlife or conserve the ecosystems that support our economy and protect our quality of life. The urgent need to cap pollution is frequently noted by commentators on the climate crisis. But many observers fail to recognize that if we reduce pollution but fail to make investments in protecting and restoring our natural resources, we will have accomplished only half the job.

To meet our fundamental ethical duty to pass on a healthy planet to our children and future generations, Congress must enact a two-part agenda in its climate and energy legislation. It must cap and reduce pollution at levels dictated by science to avoid dangerous climate change, and it must provide large-scale dedicated funding to implement new strategies that address the inevitable impacts of global warming on wildlife and natural resources. Any solution that puts a price on pollution must use some of the money paid by large polluters to repair the current and future damage they are causing.

Congress must enact legislation that offers Americans a better way to power our **future and a better way to protect the planet. Restoring America's economic health is** linked to restoring the health of our natural systems. We must address carbon pollution and the growing threats to our natural world. We cannot do one without the other, or we will fail to meet our moral obligations to the generations that will follow us.

II. CLIMATE CHANGE IS HARMING WILDLIFE AND DISRUPTING THE ECOSYSTEMS ON WHICH BOTH PEOPLE AND WILDLIFE RELY

Across the planet, carbon emissions from human activity are producing dramatic changes in the natural world, changes that have been accelerating at an astounding pace. Scientific findings since the publication of the 2007 IPCC scientific assessment suggest that the need for action is more urgent than ever. Earlier this year, scientists from around the world gathered in Copenhagen to discuss their most recent findings and concluded that the worst-case scenarios found in the 2007 assessment were being realized and even exceeded. New studies show that the melting of Arctic sea ice is vastly outpacing previous predictions, sea level rise projections must be revised dramatically upward, and

[1] IPCC, *Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [M.L. Parry, et al. (eds.)] (IPCC, 2007a).

there is a rapid new release of methane from thawing permafrost and deep sea ice. Simply put, science mandates that we act as swiftly as possible to reduce greenhouse gas emissions as deeply as possible while safeguarding natural resources threatened by global warming.

In the United States, we are seeing a wide array of changes:

- Higher average air and water temperatures (both freshwater and marine);
- Increases in average annual precipitation in wetter regions (e.g., Northeast) and decreases in drier regions (e.g., Southwest), with an increasing proportion of precipitation falling in intense downpours;
- Lengthening of the frost-free season and earlier date of last-spring freeze;
- Declines in average Great Lakes ice cover and Arctic sea ice extent and thickness. Arctic summer sea ice is rapidly disappearing – it now covers less than 1/2 the area covered in the late 20th century and is melting even faster than scientists predicted;
- More extreme heat waves;
- More extensive drought, particularly in the West. Western droughts and increasing temperatures have led to a four-fold increase in major forest fires and six-fold increase in area burned in just two decades;
- Earlier spring snowmelt and a significant decline in average snowpack in the Rocky Mountains, Cascades, and Sierra Nevada ranges;
- Accelerating rate of sea-level rise and increased ocean acidity; and
- Increase in the intensity, duration, and destructiveness of hurricanes.[2]

These physical changes are already causing significant ecosystem disruptions. Increased water temperatures in coral reefs in Southern Florida, the Caribbean, and Pacific Islands have contributed to unprecedented bleaching and disease outbreaks.[3] Increased storm events, sea level rise, and salt-water intrusion have all led to a decline in coastal wetland habitats from the Atlantic Coast to the Gulf of Mexico. Already-beleaguered salmon and steelhead from Northern California to the Pacific Northwest are now challenged by global warming-induced alteration of habitat conditions throughout their complex life cycles.[4] Forest and grassland systems throughout the West have been stressed by drought, catastrophic wildfires, insect outbreaks, and the expansion of invasive species.[5] Across North America, plants are leafing out and blooming earlier;

[2] This summary of impacts, as well as the adaptation principles and many of the case studies discussed below, including a full list of references, are drawn from Glick, P., et al., "A New Era of Conservation: Review of Climate Change Adaptation Literature" (National Wildlife Federation, 2009). (http://www.nwf.org/globalwarming/pdfs/NWFClimateChangeAdaptationLiteratureReview.pdf).
[3] Donner, S.D., Knutson, T.R., and Oppenheimer, M., "Model-based Assessment of the Role of Human-induced Climate Change in the 2005 Caribbean Coral Bleaching Event," *Proceedings of the National Academy of Sciences* 104 (2008).
[4] Janetos, A., et al., "Biodiversity," *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States* (U.S. Climate Change Science Program and Subcommittee on Global Change Research, 2008).
[5] *Ibid.*

birds, butterflies, amphibians, and other wildlife are breeding or migrating earlier; and species are shifting ranges northward and to higher elevations.[6]

These and other changes are bellwethers for what scientists project will be even more dramatic impacts in the decades to come, even if we achieve significant reductions in our emissions of heat-trapping greenhouse gases. Some studies suggest that parts of North America will experience complete biome shifts, whereby the composition and function of a region's ecological systems change.[7] For example, boreal forest vegetation is projected to continue its spread into Arctic tundra regions at northern latitudes and higher elevations, with its current southern range possibly converting to grassland or temperate forest. The southwestern U.S. is expected to shift permanently to a more arid climate with even a modest amount of additional warming.[8]

Of particular concern is the disruption of entire ecosystems. As diverse species respond to global warming in different ways, important inter-specific connections – such as between pollinators and the flowers they fertilize, or breeding birds and the insects on which they feed – will be broken.[9] Decoupling of such relationships among species can have disastrous consequences. For example, research on the Edith's checkerspot butterfly (*Euphydryas editha*) in California revealed a climate-driven mismatch between caterpillar growth and the timing of its host plant drying up at the end of the season.[10] Observations of the species in the southernmost portions of its range have shown that during periods of extreme drought, or in low snowpack years, caterpillar food plants were already half dry by the time the eggs hatched. This reduction in forage quality led to high extirpation rates among those populations.

The ecological impacts associated with climate change do not exist in isolation, but combine with and exacerbate other stresses on our natural systems. Leading threats to biodiversity include habitat destruction, alteration of key ecological processes such as fire, the spread of harmful invasive species, and the emergence of new pathogens and diseases.[11] The health and resilience of many of our natural systems are already seriously compromised by these "traditional" stressors and changes in climate will have the effect of increasing their impact, often in unpredictable ways. The loss and fragmentation of natural habitats due to the development of roads, buildings, and farms is especially worrisome because it hinders the ability of species to move across the landscape to track favorable climatic conditions.[12]

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[6] Parmesan, C., and Galbraith, H., Observed Impacts of Global Climate Change in the U.S. (Pew Center on Global Climate Change, 2004).
[7] IPCC, 2007a.
[8] Solomon, S., et al., "Irreversible Climate Change Due to Carbon Dioxide Emissions," *Proceedings of the National Academy of Sciences* 106 (2009): 1704-1709.
[9] Root, T., and Schneider, S., "Climate Change: Overview and Implications for Wildlife," *Wildlife Responses to Climate Change: North American Case Studies* [S. Schneider and T. Root (eds.)] (Island Press, 2002).
[10] Parmesan, "Climate and Species' Range," *Nature* 382 (1996): 765-766.
[11] Wilcove, D.S., et al., "Quantifying Threats to Imperiled Species in the United States," *BioScience* 48 (1998): 607-615
[12] Ibañez, I., et al., "Predicting Biodiversity Change: Outside the Climate Envelope, Beyond the Species-area Curve," *Ecology* 87 (2006): 1896-1906.

As noted above, the IPCC concluded in its most recent assessment of the science that as many as a million species of plants and animals around the world could be threatened with extinction between now and 2050 if we do not implement meaningful steps to address the problem. This unprecedented threat to our natural world recently led 612 leading experts in the biological sciences to write to Congress urging enactment of a large-scale dedicated funding mechanism to enable natural resources managers to safeguard natural resources from climate change impacts. *See* Appendix C.

III. WHEN NATURE THRIVES, AMERICA THRIVES

I would like to talk today about how Congress can face up to this dire situation and not only help wildlife and wildlife habitats survive global warming, but help them thrive.

As goes America's wildlife, so goes America. The health of wildlife and natural ecosystems is closely linked with the health of the economy, human health and safety and quality of life.

Can we weather the storm on the horizon if we do not pay careful attention to the warnings and alarms that are plain to see from the wildlife around us? Can we have safe communities and healthy families if we fail to protect the natural world we depend on for clean water, abundant food, flood protection and a strong economy? What will it be like for our kids and grandkids to grow up in America if we allow the majesty and vitality of America's great outdoors to be spoiled on our watch?

As naturalist Rachel Carson emphasized in her timeless book *Silent Spring*, wildlife provides the warning signal that enables us to take action on threats to our environment before it is too late. If we pay attention to what is happening to wildlife today from carbon emissions, we see early signs of "system failure" in many regions. For example, as the ocean warms and becomes more acidic and coral species begin to decline and disappear, we see signs of a potential breakdown in the very marine food web that people depend upon for their sustenance. As polar bears lose their hunting grounds and begin to experience reproductive failures, we see signs of a potential breakdown in an entire way of life that has evolved among the tribal people of the Arctic for many centuries. The dramatic changes we see in the tropical seas and the Arctic signal the potential for equally dramatic changes in the temperate zones if we fail to take immediate action.

In addition to serving as an important sentinel of change, wildlife serves as the foundation of rural economies throughout our nation. Fishing, hunting, hiking and other outdoor activities that rely on healthy wildlife and ecosystems contribute $730 billion to the U.S. economy. They also support nearly 6.5 million jobs and generate $88 billion in state and national tax revenue.[13] Continuation of this economic activity at or near current

[13] *The Active Outdoor Recreation Economy: a $730 Billion Contribution to the U.S. Economy* (Outdoor Foundation, 2006).

levels depends on a commitment by Congress to invest in safeguarding wildlife and ecosystems from climate change impacts.

These numbers barely scratch the surface of the vast array of ecosystem services that are vital to human existence.

Wetlands provide an important example of how the economy, human health and safety and quality of life depend on conservation. Wetlands provide essential flood control, water purification, ground and surface water supply, and wildlife habitat values. Using a very conservative estimate of $10,000 in value of benefits per acre,[14] the remaining 100 million acres of wetlands in the lower 48 states are worth roughly $1 trillion. Although the extent of overall damage to wetlands that will result from global warming is unknown - this will be determined in significant part by the actions of Congress – global warming is projected to dry up or degrade up to 90 percent of the wetlands in the nation's prairie pothole region alone.[15]

The economic benefits of forests provide another reason for urgent action to confront climate change. The U.S.'s 520 million acres of forests[16] are valued at more than $60 billion for the annual benefits they provide, such as water filtration and storage, flood protection, recreation, timber production and recreational opportunities.[17] As the climate has warmed, the area burned by fires in the western U.S. has increased six-fold and fire-fighting burdens have sky-rocketed; annual federal expenditures to prepare for and fight fires in 2007 were $3 billion, a three-fold increase from 1999.[18] The major increase in fires accelerates erosion, lowers water and air quality, and decreases timber yields, among other impacts.

Large-scale investments in forest conservation, both through strategic acquisitions and through enhanced management and restoration measures, would pay enormous dividends. For example, water utilities that rely upon surface water depend heavily on investments in forest conservation to avoid the much higher expenses associated with water treatment facilities. One study showed that for every 10 percent increase in forest cover in the source area, utilities saved *20 percent* of their water treatment and chemical costs.[19]

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[14] Costanza, R. et al. 1997. "The Value of the World's Ecosystem Services and Natural Capital." Nature 387: 253-260.

[15] Anderson, M.G., and Sorenson, L.G., "Global Climate Change and Waterfowl: Adaptation in the Face of Uncertainty," *Transaction of the 66th North American Wildlife and Natural Resources Conference* (Wildlife Management Institute, 2001): 300-319.

[16] Pimentel, D., et al., "Economic and Environmental Benefits of Biodiversity," *BioScience* 47 (1997): 747-757.

[17] Krieger, D.J., *The Economic Value of Forest Ecosystem Services: A Review* (The Wilderness Society, 2001).

[18] Government Accountability Office (GAO), 2008. Wildland Fire Management: Federal Agencies Lack Key Long- and Short-Term Management Strategies for Using Program Funds Effectively. Statement of Robin M. Nazzaro Before the Subcommittee on Interior, Environment, and Related Agencies, Committee on Appropriations, House of Representatives, February 12, 2008. GAO-08-433T.

[19] Ernst, C., et al., *Protecting the Source: Conserving Forest to Protect Water* (American Water Works Association, 2004). This statistic applies only to source areas with less than 65 percent forest cover.

Similarly, large-scale investments in restoring coastal and floodplain habitats to buffer against sea level rise and intensified storms would have substantial economic and human safety benefits. During the 1980s, there were just three weather-related natural disasters with losses of $1 billion or more. The number rapidly increased to 26 during the 1990s, and another 26 between 2000 and 2006 alone.[20] Investments in buffer zones and continuous vegetative corridors along rivers and streams, on barrier islands and along coastlines not only protect and strengthen critical ecosystems, but also reduce the amount of property at risk from catastrophic damages due to storms and sea-level rise. Such investments also promote land uses, such as recreation and agriculture, which are more compatible with storms and natural hazards. Moreover, they often promote greater groundwater infiltration, which helps moderate the impacts of intensified droughts and low flow periods that are expected to accompany climate change.

Increases in weather-related disasters associated with global warming carry more than an economic cost. The perils of weather-related disasters are exemplified by Hurricane Katrina, which caused one million evacuees to flee and more than 1,800 deaths.[21] Investing in restoring coastal wetlands and other buffers against sea level rise and intensified storms will be essential to protecting these and other communities.

Safeguarding our natural resources is also essential for achieving our nation's greenhouse gas reduction goals. A key part of these goals will be met through sequestering carbon in forests and grasslands – but only if those natural systems are sufficiently resilient to withstand the intensified floods, droughts, pests, disease and other stresses that accompany climate change.

Clearly, we must act now to safeguard our natural resources not just for aesthetic and moral reasons, but also because they serve as the foundation of our very lives and of much of our economy. What we do today will determine the well-being of our children and grandchildren, and the economic security of our country.

IV. LEGISLATION CAPPING GLOBAL WARMING POLLUTION MUST BE "CLEAN, GREEN, AND FAIR."

As the broad agreement among scientists continues to tell us, to avoid the worst effects of global warming we must limit additional warming to no more than 2 degrees

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Incomplete data prevented any conclusions regarding the benefits of adding additional forest cover to areas that already have 65 percent or greater forest cover.

[20] U.S. Climate Change Science Program (CCSP), 2008. *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands.* T.R. Karl, et al. (eds.). Department of Commerce, NOAA's National Climatic Data Center, Washington, D.C., USA, 164 pp.

[21] Brown, A., "Hurricane Katrina Pummels Three States," *CNN Transcripts* (http://transcripts.cnn.com/TRANSCRIPTS/0508/29/asb.01.html, aired August 29, 2005) and Grier, P, "The Great Katrina Migration," *Christian Science Monitor* 12 (2005).

Celsius over pre-industrial levels.[22] According to the IPCC, we have a reasonable chance of meeting this objective if developed countries, such as the United States, as a whole cut their emissions by 25-40 percent below 1990 levels by 2020 and by 80-95 percent below 1990 levels by 2050.[23]

It should come as no surprise, therefore, that NWF's top priority is enactment of legislation that places mandatory caps on global warming pollution from major emitters and invests in transforming America to a new, clean energy economy. This legislation must reduce domestic global warming pollution as swiftly as possible by 2020 and by over 80 percent by mid-century in order to protect wildlife and future generations from the most destructive impacts of climate change. If designed and implemented correctly, such legislation can also provide the financial resources needed to invest in new clean energy solutions, create millions of new jobs, protect the public from rising energy prices, *and* safeguard America's natural resources from the impacts of global warming.

The best means to accomplishing these goals is by implementing an economy-wide cap and invest system that is "clean, green, and fair." Through such a system, the nation's biggest polluters should be required to promptly and steadily reduce their pollution levels. Revenue generated from polluters paying for emission allowances can be directed to meet our moral obligation to solve global warming, facilitate a clean energy transition that is economically fair to families in all regions of the nation, protect our natural resources from the impacts of a warming climate, and take care of communities and those who are least able to respond to the changes that are coming. While the cap sets out a path to reduce global warming pollution, the choices of how we invest the financial resources generated from such a system will also determine whether we solve the climate crisis and create a low-cost, productive, and sustainable transition to a clean energy economy.

National Wildlife Federation believes that the Chairman's mark of the Clean Energy Jobs and American Power Act provides a clean, green and fair framework.

A. Investing in a Clean Energy Future

We must remember that the challenge of combating global warming also brings enormous opportunity. The shift to a clean energy economy will put millions of Americans, including those most in need, back to work in the face of our deepest economic crisis since the Great Depression. Resources generated by a cap and invest system can ensure that this opportunity is realized.

To meet the challenge of global warming, we must first transform the ways America and the rest of the world produce and use energy, achieving dramatic improvements in

[22] This temperature increase is equivalent to 3.6 degrees Fahrenheit over pre-industrial levels or about 2 degrees Fahrenheit over the amount of warming that has already occurred.
[23] IPCC, *Climate Change 2007. Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J., et al. (eds.)] (IPCC, 2007b).

the efficiency with which we use energy in our homes, businesses, and vehicles and moving to clean, renewable energy, like wind and solar power. A significant share of revenue generated by new global warming legislation must be directed toward overcoming technological or market obstacles, and toward creating new and stable jobs in key sectors, including green buildings and other efficiency improvements. These investments also must focus on building an updated smart electric grid; generating wind, solar, and geothermal electricity; designing carbon capture and storage; and transforming the transportation sector (with low carbon fuels, electric automobiles, and reduced vehicle miles traveled). And new incentives must be made available to encourage American farmers and land owners to assist in combating global warming by enhancing the sequestration of carbon on their private lands with healthy forests, sustainable agriculture, and other actions.

B. Investing in our Green Conservation Legacy

Of an equal imperative is the need to protect America's great, green legacy of conservation. As I elaborate further in the next section of this testimony, we need to ensure that our critical natural resources are protected from the growing impacts of global warming. Any solution that puts a price on global warming pollution must also use some of the resources it generates to repair the current and future damage caused by such pollution. Financial commitments are needed, and will continue to be needed, to protect and restore the land and water that people and wildlife depend on, including freshwater ecosystems, forest lands, and coastal ecosystems, so that they are more resilient. Federal climate legislation must include sufficient funding to empower natural resource managers at the national, state, local and tribal levels to identify, prioritize and protect ecosystems at risk from global warming. The investment must be dedicated, not appropriated, so that resource managers have a guaranteed source of funding for these critically important projects. This absence of fully dedicated funding was a key weakness of the American Clean Energy and Security Act passed by the House, and so the National Wildlife Federation strongly supports the provisions in the Clean Energy Jobs and American Power Act that remedy this problem.

C. Investing in Fair Solutions

We know that creating a program to reduce global warming pollution will, over time, drive major, positive changes in our homes, communities and workplaces. During this transition we need not only to protect individuals and communities from potential short-term financial hardship that could result from these changes, but also to promote the technology, training, and other investments needed to ensure that the transition brings new jobs and opportunities to every community. Long-term investments need to provide communities with new employment and educational opportunities, including urban and rural worker training programs. These will create the work force needed to build the new clean energy infrastructure.

Funding from a cap and invest program also should ensure that the economic impacts of the legislation are fair for families and consumers from all regions of the nation, and we applaud the provisions in the Clean Energy Jobs and American Power Act that do precisely that. Because low- and moderate-income households spend a larger share of their budgets on energy and other basic costs of living than others, we must make sure that any energy-related price increases are cushioned by direct consumer rebates that effectively and efficiently reach households and workers in need. Investment in energy efficiency also is crucial – it is one of the most effective means of protecting all consumers from rising energy prices because it keeps money circulating in American households and communities rather than allowing it to flow overseas to import more polluting fuels.

Our responsibility to solve global warming in a fair and equitable manner does not stop at our borders. In addition to acting at the domestic level, the U.S. must also become an international leader and forge a new climate treaty in the Copenhagen climate negotiations. Successfully resolving the global warming crisis at the international level is dependent, in part, on substantial funding for adaptation in developing countries, which are the most vulnerable to climate change impacts. The United Nations Development Program (UNDP) recently estimated that through 2016 developing countries will require approximately $86 billion per year in new adaptation funding to cope with the impacts of climate change.[24] The U.S. should lead the way toward a global solution to climate change by providing developing countries with measurable, reportable, and verifiable financing for clean energy technologies, forest conservation, and adaptation efforts that address unavoidable climate impacts. The National Wildlife Federation strongly supports the Clean Energy Jobs and American Power Act's policy measures to address these challenges and we hope to work with Congress to strengthen its commitment of funding to support these policies.

V. SAFEGUARDING NATURAL RESOURCES IN THE FACE OF CLIMATE CHANGE WILL PAY LARGE DIVIDENDS FOR PEOPLE AND WILDLIFE

A. Aggressive Action is Needed to Protect People and Wildlife from Climate Change Impacts

Conservation strategies of the past century have been carried out under the assumption that climate, weather patterns, species and habitat ranges, and other environmental factors will (or should) remain consistent with historical trends. Today, much of the environmental progress that has been achieved using these strategies is at grave risk. Continuing to operate under a "business as usual" approach will likely lead to a wave of extinctions and severe degradation of the ecosystems on which both people and wildlife depend. Given current trends of global warming and human development, a new conservation paradigm must be launched. This paradigm, referred to here as natural resources adaptation, is far more ambitious than the previous approach to conservation.

24 UNDP, "Fighting Climate Change: Human Solidarity in a Divided World," *Human Development Report 2007/2008* (UNDP, 2008) (http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf).

In essence, it calls for anticipating the harmful combined impacts to ecosystems of inevitable global warming and human development and using conservation measures to protect wildlife and people from those impacts.

Although the discipline of natural resources adaptation is a new one, a consensus is rapidly emerging among scientists and natural resource managers on the key steps that must be taken. In selecting conservation objectives and developing management strategies, natural resources adaptation experts recommend adhering to the following five principles:

1. **Reduce other, non-climate stressors.** Addressing other conservation challenges—such as habitat destruction and fragmentation, pollution, and invasive species—will be critical for improving the ability of natural systems to withstand or adapt to climate change. Reducing these stressors will increase the resilience of the systems, enabling them to recover from climate-related disturbances and return to a functional state.

2. **Manage for ecological function and protection of biological diversity.** Healthy, biologically diverse ecosystems are better able to withstand the impacts of climate change than depleted ecosystems. Ecosystem resilience can be enhanced by protecting biodiversity among different functional groups, among species within function groups, and variations within species and populations, in addition to species richness itself.

3. **Establish habitat buffer zones and wildlife corridors.** Improving habitat "connectivity" to facilitate species migration and range shifts in response to changing climate condition is an important adaptation strategy.

4. **Implement "proactive" management and restoration strategies.** Efforts that actively facilitate the ability of species, habitats and ecosystems to accommodate climate change—for example, beach renourishment, enhancing marsh accretion, planting climate-resistant species, and translocating species—may be necessary to protect highly valued species or ecosystems when other options are insufficient.

5. **Increase monitoring and facilitate management under uncertainty.** Because there will always be some uncertainty about future climate change impacts and the effectiveness of proposed management strategies, careful monitoring of ecosystem health coupled with management approaches that accommodate uncertainty will be required.

Conservation practitioners are already putting these principles into action. For example, we know that we must rebuild the coastal wetland complex in Louisiana if we are going to protect the people and wildlife of that region from the combined effects of sea level rise and intensified storms. Coastal Louisiana loses the equivalent of 32 football fields of land every day. If this rapid loss is allowed to continue, nearly 2 million people in Louisiana's coastal zone will be subjected to more frequent and severe flooding. Entire communities may have to be abandoned. Seafood and other natural resources critical to families across the country will be lost.

To address this threat, the National Wildlife Federation is working with state and federal agencies and other NGOs to restore this vast wetland complex. One very promising near-term opportunity is a project to restore the Bayou Bienvenue cypress swamp -- a 31,000 acre area in St. Bernard Parish and eastern New Orleans. This cypress forest once protected the community and its natural resources from storms, and with the support of Congress, it can do so again. Imagine the progress that could be made in protecting communities from storms and floods, and generating economic activity, if Congress were to use dedicated funding generated by cap-and-invest legislation to stimulate these kinds of habitat restoration projects across the country.

There are similar adaptation projects in early stages of planning and implementation in every region of country. These projects, and many others, await a substantial funding commitment from Congress to produce the conservation outcomes that the American people value and expect. For example:

- In New York, the Department of Environmental Conservation (DEC) is working with state Department of Transportation (DOT) on redesigning the standards for culverts under roadways across the state to take into account intensified rainfall events and to improve the connectivity of aquatic and riparian habitats. Both agencies have integrated climate change forecasts into their planning. The DEC benefits from the expanded culverts because they help reduce soil erosion, allow for sediment buildup and improve aquatic habitat; the DOT benefits because roadways are less likely to be washed away by storms.[25]

- In Massachusetts, the state is integrating principles of climate change adaptation in its ongoing watershed activities. In its Town Brook Restoration Project, agency and non-governmental organization (NGO) partners are restoring habitat and connectivity for both resident and anadromous cold water fish in Plymouth. The project entails a combination of selected dam removal, restoration of areas of natural stream bank, altering a culvert, and rebuilding a fish ladder. Anticipating the more intense rainfall events and warmer stream temperatures that accompany climate change, the state will be providing fish with more natural flow regimes as well as cold-water refugia.[26]

- Also in Massachusetts, the state is undertaking a comprehensive assessment of the climate change vulnerability of its priority wildlife habitats to understand which wildlife species and habitats will be at increased risk, and where future conservation actions will be most important. Building on the state's federally-approved wildlife action plan, this

[25] Federal Highway Administration, *Integrating Climate Change into the Transportation Planning Process* (ICF International, 2008).
[26] Massachusetts Department of Fish and Game, "Adapting to Climate Change" (http://www.mass.gov/dfwele/climatechange.htm).

vulnerability assessment is being used by state agencies and private conservation partners to alter priorities for conservation land acquisitions.[27]

- **In California's San Francisco Bay**, efforts to restore salt marsh habitat on abandoned salt evaporation ponds have been revised to take projected sea level rise into account. The U.S. Fish and Wildlife Service (FWS) is restoring these wetlands with the aim of not only providing habitat for migratory birds and endangered species but also protecting low-lying communities from flooding.[28]

- The Western Governor's Association (WGA) has recognized that healthy ecosystems and abundant wildlife are important economic drivers and that in the face of **climate change the survival of many of the West's most cherished wildlife species will** depend on protecting crucial habitats and ensuring connectivity among these habitats. To that end, it has carried out a multi-state planning effort to identify important wildlife corridors, and has established a Western Wildlife Habitat Council to coordinate and manage implementation of the wildlife corridors initiative.[29]

- On the southern tip of Florida, bleaching events in the coral reef have been increasing in number and severity due in part to warming of ocean waters. The recovery plan outline for the threatened elkhorn and staghorn coral calls for new measures to prevent land-based pollution will make corals far less susceptible to such bleaching.[30]

- In North Carolina, agencies and NGOs such as the Nature Conservancy are responding to and anticipating a significant loss of lowland wetlands due to a combination of land subsidence and sea-level rise in the Albemarle-Pamlico region. They are installing water control structures to manage water levels, to enhance marsh accretion and planting flood- and salt-tolerant plant species such as native bald cypress. In addition, they are constructing native oyster reefs along the shorelines to reduce wave energy and create new shallow-water habitats.

- **In Maryland, the state has established a "Living Shorelines" program that uses** sand-loving plants to anchor Chesapeake Bay coastal habitats in the face of sea level rise. Maryland changed its laws last year to encourage more communities to build this kind of project instead of hardened bulkheads, and awards $1.5 million a year in no-interest loans for such projects.[31] This is a departure from the costly and ecologically destructive **"armoring" approach to sea level rise, which relies on man**-made sea walls or rock piles **that has made the Chesapeake look like a "high-sided swimming pool"** in some places.[32]

[27] Ibid.
[28] FWS, "Many Partnerships Involved in South Bay Restoration," *Tideline: San Francisco Bay National Wildlife Refuge Complex* 23 (2003).
[29] WGA, Wildlife Corridors Initiative (Western Governors' Association, 2008).
[30] Grimsditch, G.D., and Salm, R.V., Coral Reef Resilience and Resistance to Bleaching (The World Conservation Union, 2005).
[31] Maryland Department of Natural Resources, "Living Shorelines" (http://shorelines.dnc.state.md.us/living.asp).
[32] Fahrenthold, D.A., "Eco-bills Come Due at Bay's Beaches," *The Washington Post*, March 19, 2009, p. A01.

- In Washington, university scientists and state agencies are working with Washington State's Watershed Planning Program to help locally-based watershed managers anticipate projected shifts in annual streamflow patterns and thereby reduce flood damage and improve stream health.

- In Oregon, the Forest Service and others modeling future climate conditions and vegetative change to project potential impacts of climate change on natural systems in the Rogue River Basin of Oregon. They project that reduced snowpack, rising temperatures, and the occurrence of drought will dry out soils and make forests more susceptible to wildfires, leading to declining forest product production to decline. As a result, managers are considering adjusting forestry management practices and post-fire logging activities, as well as adopting policies that integrate fuel reduction efforts with small scale biomass energy production.

- In Virginia and at least fourteen other states, state wildlife agencies have brought together stakeholders at workshops to update their State Wildlife Action Plans to ensure that they account for inevitable climate change.

As the above examples make clear, natural resources conservation leaders across the country are helping to launch a new paradigm for conservation, one that helps America safeguard its natural assets from the unprecedented threat of human-caused climate change. However, the financial resources available for this work have been quite limited, especially when compared to investments made in the physical sciences and in investigating the causes and mitigation of climate change.

The recently released report on adaptation by the U.S. General Accountability Office highlights how the absence of any clear national strategy, and the lack of any funding mechanism to carry out such a strategy, has hindered progress in safeguarding wildlife and people from climate change impacts. GAO's survey of federal, state and local officials revealed that, despite a broad recognition of the gravity of the climate change threat, non-adaptation projects generally receive higher priority attention than adaptation efforts from agencies due to the long-term nature of the problem and the absence of any mandate to take action. In addition, agencies are constrained in their ability to take action due to the shortage of local climate projections and other site-specific data. Another key challenge is the general absence of any delineation of roles and responsibilities.[33]

To address these substantial gaps in capacity and policy direction and to put in place a new paradigm of natural resources adaptation , Congress must make large-scale investments in the design and implementation of a national adaptation strategy as well as region-specific natural resources adaptation plans.

B. Natural Resources Adaptation Requires Strong Investments, but the Benefits Greatly Exceed the Costs

[33] *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions* (US GAO October 2009).

In May 2008, the Senate considered S. 3036, the Climate Security Act (CSA), which earlier had been approved by the Environment and Public Works Committee. Among other features benefiting wildlife and natural resources, the CSA provided an average of roughly $7 billion annually over its first two decades for natural resources adaptation in the U.S. In contrast, H.R. 2454, the American Clean Energy and Security Act passed by the House this past June, provides an average of roughly $1.7 billion over the same time period. We have not yet had the opportunity to estimate the dollar value of the investments contemplated in S. 1733, but we anticipate that it will be slightly lower than in the House bill. Of these three amounts, NWF and its conservation partners firmly believe that **last year's Senate bill** provided an appropriate level of investment for protection of U.S. natural resources threatened by climate change, given the numerous other pressing demands for those proceeds.

Although no study has yet tabulated the full cost of conserving species and ecosystems in the face of climate change, it is clear that the cost will be far greater than $7 billion annually. For example, a series of studies on the costs of restoring the Everglades, Chesapeake Bay and Great Lakes suggests that the cost over five years ranges from at least $10 billion to $20 billion each.[34] Another study found that $350 billion would be needed over 30 years to make up a viable habitat conservation network across the lower 48 states (using conservation easements to acquire interests in land).[35]

Although most of the conservation actions considered in these studies would build ecosystem resiliency in the face of climate change, it should be emphasized that these studies did not specifically take into account the impacts of climate change in arriving at their cost estimates.[36] Considering that climate change adds a large stressor on top of existing stressors, Congress should assume that these cost estimates significantly understate the overall costs of conserving ecosystems in the face of climate change.

Despite this large price tag, Congress must recognize that, as discussed above, the economic benefits of conservation reach into the hundreds of billions annually and therefore far exceed the costs. In essence, healthy, well-functioning ecosystems provide the foundation for a healthy economy.

Some will argue that Congress should postpone to another day the funding of natural resources adaptation. This would be a foolish approach. As each day passes where conservation action is delayed, the costs of inaction continue to mount. More and more

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[34] CRS Report for Congress: Ecosystem Restoration in the Great Lakes: The Great Lakes Regional Collaboration Strategy (January 30, 2008).

[35] Casey, F., et al., *The Cost of a Comprehensive National Wildlife Habitat Conservation System* (Defenders of Wildlife, 2008). The study drew from a sample of maps prepared by state and fish wildlife agencies in developing State Wildlife Action Plans, which are largely oriented toward terrestrial habitats.

[36] Presumably, most adaptation measures will use existing conservation tools and approaches, but climate change information will necessitate changes in the timing, location and scale in which they are employed. Natural resources adaptation also will inevitably require the development of novel tools and approaches. Unfortunately, little federal research and development funding to date has gone into adaptation planning and implementation. Substantial public investments are needed to spur innovation in this area.

species spiral toward extinction and ecosystems become further degraded. Over time, the options for restoring them will become increasingly reduced and more costly.

C. A Dedicated Funding Mechanism in Climate Legislation is Essential to Meeting the Challenge of Safeguarding Wildlife and Natural Resources from the Impacts of Climate Change

As noted above, National Wildlife Federation and its conservation partners are extremely pleased that S. 1733 provides a permanent source of dedicated funding, using pollution allowances, for natural resources adaptation. We also pleased that this dedicated funding is broadly distributed among federal, state and tribal natural resources agencies.[37] These agencies already have the program delivery infrastructure in place to quickly put natural resources adaptation projects on the ground. In addition, with their well-established cooperative grant programs, they are well-positioned to distribute funds to private landowners and companies that have historically played leadership roles in natural resources protection and restoration. These private sector enterprises will provide crucial environmental jobs, especially in rural areas of the country where local economies depend heavily on a healthy natural resources base.

In contrast, H.R. 2454, passed by the House in June, provides a dedicated source of funding only to the states. Under the House bill, federal agencies must rely upon the annual appropriations process to meet their obligations to safeguard wildlife and natural resources from the impacts of global warming. Adopting this approach in the Senate would be a mistake. First, the amounts that would potentially available through the appropriations process would not come close to meeting the scope of the challenge. Second, natural resource adaptation projects are necessarily multi-year endeavors, requiring long-term planning and predictable investments. Finally, this nation has long adhered to the principle of "polluter pays." Thus, in determining how to address the harmful impacts of global warming, it is entirely appropriate to use dedicated funding generated by those who emit global warming pollution into the atmosphere. In allocating proceeds of the sale of global warming pollution allowances, Congress should highlight how these proceeds are addressing both the causes and effects of this pollution.

Finally, we are pleased that S. 1733 provides funding to general adaptation programs such as water utility adaptation, wildfire reduction and coastal infrastructure protection. We also are pleased that the bill recognizes the importance of using natural systems to provide buffers against storms and floods and to provide filtration services for drinking water utilities. However, Congress should resist any temptation to create a single dedicated fund for these types of adaptation as well as natural resource adaptation. Natural resources adaptation requires a distinct approach and a distinct funding source.

[37] As sovereign nations and managers of 95 million acres of land, Indian tribes will play a crucial role in helping wildlife and natural resources survive climate change.

D. The Broad Array of Groups that Have Mobilized in Support of the Safeguarding Natural Resources Agenda Shows its Urgency and Importance

As noted above, NWF participates in a diverse coalition of roughly 600 conservation and sporting organizations that have joined in an effort to secure large-scale dedicated funding for wildlife and natural resources in federal climate change legislation. Recently, conservation and sporting organizations from every state in the nation sent two letters to the Senate urging enactment of comprehensive climate and energy legislation that reduces greenhouse gas emissions and provides dedicated funding for natural resources adaptation. *See* Appendices A and B. As these letters make clear, our coalition recognizes the crucial importance of ensuring that spending of natural resource adaptation funds is done strategically. We recommend that all spending be guided by national and state-level adaptation strategies, and that such strategies be integrated with large-landscape conservation plans such as State Wildlife Action Plans. In addition, such strategies must be based on sound science and developed with broad public participation and input.

In summary, NWF urges Congress to cap and reduce pollution at levels dictated by science to avoid dangerous climate change, and to provide large-scale dedicated funding to safeguard wildlife and natural resources from climate change impacts. Thank you again for the opportunity to testify today.

September 15, 2009

Dear Senator,

On behalf of our organizations and the millions of individuals from across the country we represent, we urge you to work with your colleagues to **ensure the Senate passes comprehensive climate and energy legislation that reduces greenhouse gas emissions and dedicates 5% of the total allowance value for natural resources adaptation** in order to safeguard fish and wildlife, and the natural resources on which we all rely.

These funds will provide crucial support for job-creating conservation initiatives to protect natural resources which are the backbone of public health and the American economy. Across the country construction crews, engineers, scientists and others will be employed to restore America's landscapes, strengthen ecosystems so they can withstand disruptive changes, remove invasive species from natural areas, repair damaged watersheds and help revive rural economies.

Healthy natural systems provide clean water, clean air and protect communities from catastrophic weather-related disasters, ranging from hurricanes to floods to forest fires. **Outdoor recreation, including hunting, fishing, camping, climbing, hiking, paddling, backcountry skiing, mountain biking, wildlife viewing, and other activities accounts for 8% of all consumer spending, which drives an overall annual contribution of $730 billion to the economy, supporting 6.5 million jobs** (1 of every 20 jobs in the U.S.), according to The Outdoor Industry Foundation. The economic value of the natural environment is far higher when the vast range of ecosystem services is also included; conservative estimates tally these benefits at trillions of dollars annually.

Climate change poses an immediate and profound threat to the healthy natural systems that provide us with drinking water, flood protection, food, medicine, timber, recreational opportunities, scenic beauty, jobs, and numerous other services. Given these threats, climate legislation must both reduce greenhouse gas emissions and invest in our natural resources that will provide huge economic benefits for generations. **Local, state, federal, and tribal fish, wildlife and land managers are critically short of funding needed to effectively respond to the combination of these challenges to help safeguard our natural resources, fish and wildlife in a warming world.** The effort will be substantial and adequate resources are necessary.

As the Senate develops comprehensive climate and energy legislation, your leadership is needed to get the whole job done this year. **Please ensure climate legislation both reduces the greenhouse gas emissions triggering climate change *and* safeguards natural resources, wildlife and our own communities threatened by the changes already set in motion.** Specifically, any Senate bill should: establish a national policy framework to begin addressing the impacts of climate change on our natural resources; provide increased scientific capacity, coordination and information sharing; and dedicate 5% of the total allowance value to federal, state and tribal agencies to implement identified actions needed to conserve natural resources in a warming world.

We appreciate your consideration of this request.

Sincerely,
The Undersigned Organizations

National Organizations

Access Fund
American Canoe Association
American Fisheries Society
American Fly Fishing Trade Association
American Hiking Society
American Land Conservancy
American Rivers
American Whitewater
Association for Experiential Education
Botanic Gardens Conservation International
Center for Biological Diversity
Coalition of National Park Service Retirees
Defenders of Wildlife
Earthjustice
Endangered Species Coalition
International Mountain Bicycling Association
Izaak Walton League of America
National Association of State Foresters
National Audubon Society
National Parks Conservation Association
National Tribal Environmental Council
National Wildlife Federation
National Wildlife Refuge Association
Nature Abounds
NatureServe
Ocean Conservancy
Oceana
Outdoor Alliance
Outdoor Industry Association
PRBO Conservation Science
Restore America's Estuaries
Sierra Club
The Nature Conservancy
Trust for Public Land
The Wilderness Society
The Wildlife Society
Watchable Wildlife, Inc.
Waterkeeper Alliance
Wildlife Conservation Society
Wildlife Forever
Winter Wildlands Alliance
Xerces Society for Invertebrate Conservation

Regional and Local Organizations

1000 Friends of Florida
Alabama Rivers Alliance
Alaska Chapter of The Wildlife Society
Alaska Conservation Alliance
Alaska Geographic
Albany Audubon
Albuquerque Wildlife Federation
Allegheny Plateau Audubon Society
Alliance for Sustainability
Alliance for the Great Lakes
Amigos Bravos
Amigos de la Sevilleta, Sevilleta National Wildlife Refuge
Animal Protection of New Mexico
Animal Protection Voters
Appalachian Mountain Club
Arborway Coalition
Arizona Chapter of The Wildlife Society
Arizona Ecumenical Earth Care Commission
Arizona Interfaith Power and Light
Arizona Native Plant Society
Arizona Wilderness Coalition
Arizona Wildlife Federation
Arizona Zoological Society
Arkansas Wildlife Federation
Arthur R. Marshall Foundation, Arthur R. Marshall Loxahatchee National Wildlife Refuge
Association of Northwest Steelheaders
Audubon Alaska
Audubon Arizona
Audubon Colorado
Audubon Connecticut
Audubon Dakota
Audubon Gulf Coast Initiative
Audubon Miami Valley
Audubon Minnesota
Audubon Missouri
Audubon Nebraska
Audubon New Mexico
Audubon New York
Audubon North Carolina
Audubon of Florida
Audubon Pennsylvania
Audubon Society of Forsyth County
Audubon Society of Northern Virginia
Audubon Society of Ohio
Audubon Society of the Capital Region
Audubon South Carolina
Audubon Texas
Audubon Wyoming
Back Bay Restoration Foundation
Back Country Coalition in San Diego County
Badlands Conservation Alliance
Berkshire Environmental Action Team
Big Thicket Association
Biodiversity Conservation Alliance
Boulder County Audubon Society

Boulder County Nature Association
Brown County Chapter, Izaak Walton League of America
Buena Vista Audubon Society
Bush Lake Chapter, Izaak Walton League of America
BYM Unity With Nature Committee
Cabeza Prieta Natural History Association, Cabeza Prieta National Wildlife Refuge
Caddo Lake Institute, Inc.
California Coastal Coalition
California Native Plant Society
California Oak Foundation
California Wildlife Foundation
Californians for Western Wilderness
Canton Audubon Society
Cape Fear Audubon Society
Cape Fear Friends of Wildlife
Cape Fear Garden Club
Center for Native Ecosystems
Central Mountains & Plains Section of The Wildlife Society
Central New Mexico Audubon Society
Central New York Chapter, Izaak Walton League of America
Central Oregon Audubon Society
Central Sierra Audubon Society
Central Sierra Environmental Resource Center
Central Texas Audubon Society
Chapter 692, Trout Unlimited
Chesapeake Bay Foundation
Chihuahuan Desert Open Space Committee
Choctawhatchee Audubon Society
Citizens Campaign for the Environment
Citizens Committee to Complete the Don Edwards San Francisco Bay National Wildlife Refuge
Clark Fork Coalition
Climate Change Conservation Corps
Clover Valley Foundation
Coalition for Sonoran Desert Protect
Coalition to Restore Coastal Louisiana
Colorado Chapter of the Wildlife Society
Colorado Environmental Coalition
Colorado Wildlife Federation
Columbia Gorge Refuge Stewards
Columbus Platte County Izaak Walton League of America
Connecticut Forest and Park Association
Connectivity for Wildlife LLC
Conservation Council for Hawai'i
Conserve Wildlife Foundation of New Jersey
Copper River Watershed Project
Cortland Chapter, Izaak Walton League of America
Ding Darling Wildlife Society, J.N. "Ding" Darling National Wildlife Refuge
Delaware Audubon Society
Delaware Chapter of The Nature Conservancy
Delaware Nature Society
Delaware River Greenway Partnership
Delta Chapter, Izaak Walton League of America
Desert Protective Council
Downeast Audubon
Dwight Lydell Chapter, Izaak Walton League of America
Earth Conservation Corps
Eldorado Energy Cooperative
Elisha Mitchell Audubon Society
Elkhorn Slough Foundation
Endangered Habitats League
Environment Council of Rhode Island
Environmental Advocates of New York
Environmental and Cultural Conservation Organization
Environmental Association of St. Thomas/St. John
Environmental League of Massachusetts
Environmental Protection Information Center
Evansville Audubon Society
Everglades Foundation
FAVOR – Friends and Volunteers of the Florida Keys
Fenton Chapter, Izaak Walton League of America
Ferdinand Hayden Chapter of Trout Unlimited
Firelands Audubon Society
Five Valleys Audubon
Florida Chapter of The Wildlife Society
Florida Renewable Energy Association
Florida Wildlife Federation
Flycasters of San Jose
Food Conspiracy Co-op
For The Bayou
Forrlace, Inc.
Fort Worth Audubon Society
Four Harbors Audubon Society
Four Rivers Audubon
Fox Lake Conservation League
Freshwater Future
Friends of Acadia
Friends of Alaska National Wildlife Refuges
Friends of Anahuac National Wildlife Refuge
Friends of Aransas and Matagorda Island National Wildlife Refuge
Friends of Assabet National Wildlife Refuge
Friends of Black Bayou National Wildlife Refuge
Friends of Blackwater National Wildlife Refuge
Friends of Bombay Hook National Wildlife Refuge
Friends of Bon Secour National Wildlife Refuge

Friends of Buenos Aires National Wildlife Refuge
Friends of Cabeza Prieta
Friends of Caddo Lake National Wildlife Refuge
Friends of Cape May National Wildlife Refuge
Friends of Chassahowitzka National Wildlife Refuge
Friends of Chickamauga and Chattanooga National Military Park
Friends of Clarks River National Wildlife Refuge
Friends of Crane Meadows National Wildlife Refuge
Friends of Deer Flat National Wildlife Refuge
Friends of Erie National Wildlife Refuge
Friends of Forsythe National Wildlife Refuge
Friends of Great Falls Discovery Center/Silvio O. Conte National Wildlife Refuge
Friends of Great Swamp National Wildlife Refuge
Friends of Hakalau Forest National Wildlife Refuge
Friends of Harbors, Beaches and Parks, Inc.
Friends of Haystack Rock, Oregon Islands National Wildlife Refuge
Friends of Heinz Refuge at Tinicum
Friends of Humboldt Bay National Wildlife Refuge
Friends of Iriquois National Wildlife Refuge
Friends of Ironwood Forest
Friends of Kenai National Wildlife Refuge
Friends of Laguna Atascosa National Wildlife Refuge
Friends of Lake Woodruff National Wildlife Refuge, Inc.
Friends of Las Vegas National Wildlife Refuge
Friends of Louisiana Wildlife Refuges, Inc.
Friends of Maga Ta-Hophi Waterfowl Production Area
Friends of Maine Seabird Islands, Maine Coastal Islands National Wildlife Refuge
Friends of Necedah National Wildlife Refuge
Friends of Nisqually National Wildlife Refuge
Friends of Noxubee National Wildlife Refuge
Friends of Patoka River National Wildlife Refuge
Friends of Patuxent, Patuxent National Wildlife Refuge
Friends of Pondicherry, Silvio O. Conte National Fish and Wildlife Refuges
Friends of Pool 9, Upper Mississippi River National Fish and Wildlife Refuge
Friends of Prime Hook National Wildlife Refuge
Friends of Red River National Wildlife Refuge
Friends of Rock Creek's Environment
Friends of Seal Beach National Wildlife Refuge
Friends of Sherburne National Wildlife Refuge
Friends of Shiawassee National Wildlife Refuge
Friends of Squaw Creek National Wildlife Refuge
Friends of St. Catherine Creek National Wildlife Refuge
Friends of Sunkhaze Meadows National Wildlife Refuge
Friends of Supawna Meadows National Wildlife Refuge
Friends of Swainson's Hawk
Friends of Tampa Bay National Wildlife Refuges
Friends of Tennessee National Wildlife Refuges
Friends of the 500th, Canaan Valley National Wildlife Refuges
Friends of the Alameda Wildlife Refuge
Friends of the Arthur R. Marshall Loxahatchee National Wildlife Refuge
FRIENDS of the Blue Ridge Parkway, Inc.
Friends of the Bosque del Apache National Wildlife Refuge
Friends of the Cahaba River National Wildlife Refuge
Friends of the Everglades
Friends of the Florida Panther Refuge
Friends of the Kofa National Wildlife Refuge
Friends of the Little Pend Oreille National Wildlife Refuge
Friends of the Lower Suwannee and Cedar Keys National Wildlife Refuges
Friends of the Mid-Columbia River Wildlife Refuges
Friends of the Minnesota Valley
Friends of the Missouri Breaks Monument
Friends of the Montezuma Wetlands Complex, Montezuma National Wildlife Refuge
Friends of the Morris Wetland Management District
Friends of the National Wildlife Refuges of Rhode Island
Friends of the North Fork and White Rivers
Friends of the Potomac River Refuges
Friends of the Prairie Learning Center, Neal Smith National Wildlife Refuge
Friends of the Reach, Hanford Reach National Monument-Saddle Mountain National Wildlife Refuge
Friends of the Ridgefield National Wildlife Refuge
Friends of the River
Friends of the San Diego Wildlife Refuges
Friends of the Savannah Coastal Wildlife Refuges, Inc.
Friends of the Southwest Louisiana National Wildlife Refuges and Wetlands
Friends of the Trinity River National Wildlife Refuge
Friends of the Trinity Strand Trail
Friends of the Upper Mississippi River Refuges
Friends of Tualatin River National Wildlife Refuge
Friends of Wallkill River National Wildlife Refuge
Friends of Wertheim National Wildlife Refuge
Friends of Windom Wetland Management District
Galveston Bay Foundation
Gary Borger Trout Unlimited Chapter of Northern Illinois
Gaviota Coast Conservancy
Genesee Valley Audubon Society

Georgia Council of Trout Unlimited
Georgia River Network
Georgia Wildlife Federation
Gila Resources Information Project
Go Green Tullahoma
Gold Country Fly Fishers
Golden Gate Audubon Society
Golden Gate Raptor Observatory
Grand Canyon Wildlands Council
Great Dismal Swamp Coalition, Great Dismal Swamp National Wildlife Refuge
Great Egg Harbor Watershed Association
Great Lakes Committee, Izaak Walton League of America
Great Lakes Council of the Federation of Fly Fishers
Great Lakes Environmental Law Center
Great Old Broads for Wilderness
Great Salt Lake Audubon
Great South Bay Audubon Society
Greater Mohican Audubon Society
Green Faith Alliance
Greenspace – The Cambria Land Trust
Gulf Restoration Network
Habitat and Wildlife Keepers
Hellgate Hunters and Anglers
High Country Citizens' Alliance
Highlands Coalition
Highlands Plateau Audubon Society
Hills for Everyone
Hilton Head Audubon Society
HOMES
Houston Audubon
Hudson Highlands Land Trust
Huntington Audubon Society
Huron River Watershed Council
Idaho Rivers United
Illinois Council of Trout Unlimited
Indiana Wildlife Federation
Iowa Wildlife Federation
Izaak Walton League of America, Berks County Chapter
Izaak Walton League of America, Brownsville Area Chapter
Izaak Walton League of America, Cumberland Valley Chapter
Izaak Walton League of America, Fairmount Springs Chapter
Izaak Walton League of America, Franklin County Chapter
Izaak Walton League of America, Harry Enstrom Chapter
Izaak Walton League of America, John Harris Chapter
Izaak Walton League of America, Lancaster Red Rose Chapter
Izaak Walton League of America, Lebanon County Chapter
Izaak Walton League of America, Oil City Chapter
Izaak Walton League of America, Pennsylvania Division
Izaak Walton League of America, Uniontown Chapter
Izaak Walton League of America, York County Chapter
Jackson Audubon
Jackson-Macon Conservation Alliance
Johnston Co. Wildlife Association
Juniata Valley Audubon
Kalamazoo River Sturgeon for Tomorrow
Kalmiopsis Audubon Society
Kansas Chapter of The Wildlife Society
Kentucky Chapter of The Wildlife Society
Kentucky Resources Council
Kern Audubon Society
Keystone Conservation
Kilauea Point Natural History Association, Kilauea Point National Wildlife Refuge
Kilowatt Ours
Kitchen Table Climate Study Group
Klamath Forest Alliance
Kodiak Audubon
La Purisima Audubon Society
LaBarque Watershed Stream Team Association
Ladies in the Stream
Lake Erie-Allegheny Earth Force
Lake Erie Islands Chapter, Black Swamp Conservancy
Lake Erie Region Conservancy
League of Ohio Sportsmen
Lehigh Valley Audubon Society
Life Net Nature
Low Impact Wildlife Photography
Mackinac Bands of Ottawa and Chippewa Indians
Madison Audubon Society
Madrone Audubon Society
Maine Audubon
Malheur Wildlife Associates, Malheur National Wildlife Refuge
Mansfield Outdoor Club
Martin County Conservation Alliance
Maryland/Delaware Chapter of The Wildlife Society
Mary's Peak Chapter, Izaak Walton League of America
Maui Forest Bird Recovery Project
Meadowlark Audubon Society
Members of Mission Peak Fly Anglers
Mesilla Valley Audubon Society
Michigan Audubon
Michigan Energy Alternatives Project
Michigan Environmental Council
Middle Nolichucky Watershed Alliance

Midwest Environmental Advocates
Minnesota Chapter of The Wildlife Society
Minnesota Conservation Federation
Minnesota Division, Izaak Walton League of America
Mississippi Chapter of The Wildlife Society
Mississippi River Wild, Upper Mississippi River National Fish and Wildlife Refuge
Missouri Smallmouth Alliance
Missouri Stream Team 2991
Missouri Votes Conservation
Mobile Bay Audubon Society
Mojave Desert Bird Club
Mon Valley Ladies Chapter, Izaak Walton League of America
Monmouth County Audubon
Monroe County Federation of Sportsmen's Clubs
Montana Audubon
Montana Rivers
Monterey Coastkeeper
Musicians United to Sustain the Environment
Muskingum Watershed Conservancy District
Native Fish Society
Natural Resources Council of Maine
Nebraska Birding Trails
Nebraska Chapter of The Wildlife Society
Nebraska Rural Living
Nebraska Wildlife Federation
Nevada Wildlife Federation
New England Chapter of The Wildlife Society
New Hope Audubon Society
New Jersey Audubon Society
New Jersey Chapter of The Wildlife Society
New Jersey State Federation of Sportsmen's Clubs
New Mexico Audubon Council
New Mexico Chapter of The Wildlife Society
New Mexico Wildlife Federation
New York Chapter of The Wildlife Society
New York State Trappers Association
North Carolina Chapter of The Wildlife Society
North Carolina Coastal Federation
North Carolina Trout Unlimited State Council
North Carolina Wildlife Federation
North Carolina Wildlife Federation, Central Chapter
North Carolina Wildlife Federation, Mountain Island Chapter
North Central Washington Audubon Society
North Country Trail Association
North Dakota Natural Resources Trust
North Dakota Wildlife Federation
North Fork Audubon Society
Northeast Arkansas Flyfishers
Northeast Wilderness Trust
Northern California Council, Federation of Fly Fishers
Northern California River Watch
Northern Catskills Audubon Society
Northern Forest Alliance
Northern Jaguar Project
Northern Neck of Virginia Audubon Society
Northwest Guides and Anglers Association
Northwest Section of The Wildlife Society
Oblong Land Conservancy
Ocean Revolution
Ohio Bass Federation
Ohio Division, Izaak Walton League of America
Ohio Game Fishing, LLC
Okefenokee Wildlife League, Inc., Okefenokee National Wildlife Refuge
Oklawaha Valley Audubon Society, Inc.
Oktibbeha Audubon Society
Oregon Division, Izaak Walton League of America
Oregon Natural Desert Association
Organization for Bat Conservation
Organization for Wildlife and Land Stewardship
Oro Valley Neighborhood Coalition
Ozark Fly Fishers
PACT in the High Country
Palomar Audubon Society
Palos Verdes/South Bay Audubon Society
Panhandle Conservation Council
Partnership for Earth Spirituality
Payne County Audubon Society
Pelican Island Preservation Society, Pelican Island National Wildlife Refuge
PennFuture
Penns Creek Guides
Pennsylvania Chapter of The Wildlife Society
Pennsylvania Interfaith Climate Change Campaign
People for Land and Neighborhoods
People for Puget Sound
Pike County Federation of Sportsmen's Clubs
Planning and Conservation League
Plumas Audubon Society
Pomona Valley Audubon Society
Pomperaug River Watershed Coalition
Portneuf Valley Audubon Society
Prairie Rivers Network
Primate Conservation, Inc.
Primitive Living Skills of Texas
Pulaski Chapter of the Ozark Society
Quiet Use Coalition
Rappahannock Wildlife Refuge Friends Group
RE Sources for Sustainable Communities

Red Rock Forests
Redwood Empire Chapter, Trout Unlimited
Redwood Region Audubon Society

Refuge Friends Inc, Minnesota Valley National Wildlife Refuge
Religious Coalition for the Great Lakes
Renewable Resources Coalition
Respect the Snake
Restoring Eden
Richland Creek Watershed Alliance
Richmond Audubon Society
River Ridge EE Program
River Source, Inc.
Rocky Mountain Flycasters
Rocky Mountain Recreation Initiative
Rogue Valley Audubon Society
RW Parkinson Consulting, Inc.
Sacramento-Shasta Chapter of The Wildlife Society
San Bernardino Valley Audubon Society
San Diego Audubon Society
San Francisco Bay Area Chapter of The Wildlife Society
San Joaquin Raptor/Wildlife Rescue Center
San Joaquin Valley Conservancy
San Juan Citizens Alliance
San Luis Valley Ecosystem Council
Sangre de Cristo Audubon Society
Santa Barbara Audubon Society
Save the Bay
Save the Manatee Club
Save Our Shores
SCENIC GALVESTON, Inc.
Scenic Hudson
Scioto Valley Bird and Nature Club
Sea and Sage Audubon Society
Sensible Management of Aquatic Resources Team
Sequoia Audubon Society
Sheep Mountain Alliance
Sierra Nevada Alliance
Silverton Chapter, Izaak Walton League of America
Sisters of St. Francis of Assisi
Sisters of St. Joseph of Rochester
Sky Island Alliance
Snook Foundation
South Carolina Nature-Based Tourism Association
South Carolina Wildlife Federation
South Dakota Izaak Walton League
South Dakota Wildlife Federation
South Florida Audubon Society
Southern Appalachian Forest Coalition
Southern Arizona Coalition on the Environment and Jewish Life
Southern Utah Wilderness Alliance
Southside Presbyterian, Tucson
Southwest Environmental Center
Southwestern Biological Institute
Southwestern Herpetologist Society
Space Coast Climate Change Initiative
Spokane Riverkeeper
St. Cloud Area Green Party
St. Louis Audubon Society
St. Lucie Audubon Society
St. Marks Refuge Association
St. Petersburg Audubon Society
Steve Vrooman Restoration Ecology
Stewards of the Upper Mississippi River Refuge, Savannah District
Stone Lakes National Wildlife Refuge Association
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Sustainable Conservation
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Talking Federation
Tamarac Interpretive Association, Tamarac National Wildlife Refuge
Tampa Audubon Society
Technicians for Sustainability
Tennessee Clean Water Network
Tennessee Environmental Council
Tennessee Interfaith Power & Light
Tennessee Ornithological Society
Tennessee Parks and Greenways Foundation
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Texas Chapter of The Wildlife Society
Texas Conservation Alliance
The Chewonki Foundation
The Conservancy for the Parthenon
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The Friends of Valley Forge Park
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The Land Trust for the Little Tennessee
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The Open Space Council for the St. Louis Region
The Otter Project
The Wildlife Center
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Tierra Vista Tours & Consulting
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Tom Balz Fly Fishing
Travis Audubon
Trout Unlimited, Arrowhead Chapter

Trout Unlimited, Chestnut Ridge Chapter
Trout Unlimited, Gold Rush Chapter
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Western Watersheds Project
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Wisconsin Metro Audubon Society
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Wray-Todd Ranch, LLC
Wrightsville Beach Sea Turtle Project
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American Fisheries Society * American Fly Fishing Trade Association * American Sportfishing Association * Association of Fish and Wildlife Agencies * Berkley Conservation Institute * Campfire Club * Dallas Safari Club * Ducks Unlimited * Houston Safari Club * Izaak Walton League of America * Mule Deer Foundation * National Trappers Association * National Wildlife Federation * Pheasants Forever * Quality Deer Management Association * The Wildlife Society * Theodore Roosevelt Conservation Partnership *Trout Unlimited * Wildlife Forever * Wildlife Management Institute

September 21, 2009

Dear Senator,

On behalf of the millions of organized sportsmen and women and conservation professionals from across the country, we urge you to work with your colleagues to ensure that the Senate passes comprehensive climate and energy legislation this year. In order to safeguard fish, wildlife, and their habitats which also provide for ecosystems services and quality of life for our citizens, we urge that legislation must include both reductions of greenhouse gas emissions and dedication of an adequate and appropriate amount of the total carbon allowance value for natural resources adaptation programs at the federal and state levels.

Hunting, fishing, and wildlife related recreation generate more than $172 billion annually in economic activity at the state and local level, which equates to 1% of the gross domestic product. Climate change poses an immediate and profound threat to fish and wildlife, and the healthy natural systems that provide us with clean drinking water, flood protection, food, medicine, timber, biomass, recreational opportunities, scenic beauty, jobs, and numerous other services. Given these threats, climate legislation must both reduce greenhouse gas emissions *and* invest in our natural resources so that they will continue to provide substantial social and economic benefits for generations. State, federal, and tribal fish, wildlife and land managers are critically short of funding needed to effectively respond to the combination of these challenges to help safeguard our natural resources in a changing climate. The adaptation effort will be substantial, and adequate resources are necessary in order to be successful.

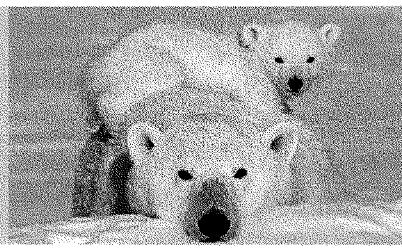
Our federal public lands are more important than ever in maintaining sustainable ecosystems that deliver services to our citizens, reduce carbon in the atmosphere through sequestration, and maintain viable populations of fish and wildlife with associated quality hunting and fishing opportunities. Public lands also provide crucial habitat linkages and connective migration corridors for fish and wildlife and their management should be directed towards climate change adaptation by the federal land management agencies.

The state fish and wildlife management agencies and the federal land management, natural resources management, and agriculture agencies will be critical components in a viable national climate change strategy and should receive dedicated funding to implement natural resource adaptation measures and strategies to remediate the effects of climate change on fish, wildlife and their habitats. It is equally important that these agencies engage the private farm, ranch, and forest landowners with technical assistance and financial incentives to reduce emissions and sequester carbon on their lands. In fact, it will be critical to ensure that management of state, federal, tribal, and private forests is conducted in a manner that maximizes their resiliency to climate change and reduces the future likelihood of intense fires that can put enormous quantities of carbon dioxide into the atmosphere when released from trees and soils.

We need not create new state or federal bureaucracies to receive and administer funds for natural resources adaptation to be implemented consistent with national and state adaptation strategies to be developed under the provisions of a comprehensive climate and energy bill. Existing programs such as the Wildlife Restoration Act, Sportfish Restoration Act, Coastal Management Act of 1972, and Land and Water Conservation Fund of 1965 already have established procedures, rules, and accounts capable of getting money to the agencies efficiently. Further, a USDA administered offset program would encourage farmers and landowners to implement carbon sequestration activities through land management and conservation programs. For example, the restoration of grasslands and protection of native prairie will sequester tons of carbon on private lands while greatly enhancing nesting habitat for waterfowl and other grassland nesting birds. This approach of protecting, reconnecting, and restoring landscapes will have significant benefits for human communities. Protecting high elevation drinking water supplies will reduce water filtration costs. Reconnecting rivers to floodplains will reduce downstream flooding costs. Restoration activities such as thinning unnaturally dense forest stands near communities will provide high paying, family-wage jobs while insulating communities from the effects of intense wildfires. Use of this harvested cellulosic biomass can also enhance our reliance on renewable energy, thus further reducing carbon emissions.

As the Senate develops comprehensive climate and energy legislation, your leadership is needed to get the job done this year. Please ensure that the climate legislation you consider in the Senate both reduces greenhouse gas emissions and safeguards natural resources, fish, wildlife and our own communities threatened by the changes already set in motion by changing climate effects. Specifically, any Senate bill should establish a national policy framework to help protect, reconnect, and restore public and private lands; provide increased scientific capacity; identification of wildlife migration corridors; coordination and information sharing; and dedicate an adequate amount of the total allowance value to federal, state and tribal agencies to implement identified actions needed to conserve natural resources in a climate change bill. We are appreciative of the natural resource adaptation funding levels in the House-passed bill, and urge you to increase those funding levels if at all possible. We further acknowledge the advocacy of other sportsmen's groups for consideration of the need for and role of other low-carbon based energy sources in a comprehensive climate and clean energy bill.

Thank you for your consideration of this most important issue.



NATIONAL WILDLIFE FEDERATION

A Letter from Scientists to the United States Congress Urging Action to Address the Threats of Global Warming to Wildlife and Ecosystems

FEBRUARY 2008

"We write to you to convey our sense of urgency. Global warming is already causing serious damage and disruptions to wildlife and ecosystems, and reliable projections call for significant additional damage and disruptions. To fulfill the nation's longstanding commitment to conserving abundant wildlife and healthy ecosystems for future generations, Congress must craft legislation that greatly reduces greenhouse gas pollution and generates substantial dedicated funding to protect and restore wildlife and ecosystems harmed by global warming."

– 612 Scientific Experts Concerned About Global Warming and Its Effect on Wildlife and Natural Resources, including

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A Letter from More Than 600 Scientists to the United States Congress Requesting Adequate Funding to Address the Threats to Wildlife Posed by Global Warming

Dear Members of Congress,

The undersigned signatories are leading researchers and practitioners from the various disciplines of biological science. We understand that Congress is currently considering a number of proposals to reduce U.S. emissions of greenhouse gases (GHGs) and thereby confront global warming. We applaud this effort. Global warming represents, by far, the greatest threat ever posed to the planet's living resources, which provide the foundation for our economy and our quality of life. We write to you to convey our sense of urgency. Global warming is already causing serious damage and disruptions to wildlife and ecosystems, and reliable projections call for significant additional damage and disruptions. To fulfill the nation's longstanding commitment to conserving abundant wildlife and healthy ecosystems for future generations, Congress must craft legislation that greatly reduces GHG pollution and generates substantial dedicated funding to protect and restore wildlife and ecosystems harmed by global warming.

The following examples of damage and disruptions to wildlife and ecosystems caused by GHG pollution and global warming are among the most noteworthy:

- Melting polar ice caps
- Thawing permafrost
- Acidification of the oceans
- Sea level rise
- Intensified storms
- Warming of rivers, streams, lakes and estuaries
- Declining snowpack on mountains and earlier runoff
- Drought
- Catastrophic fires
- Pest infestations
- Spreading pathogens and invasive species
- Changes in phenology (seasonal events) and distributions of wildlife populations, separating predators from prey and otherwise disrupting ecological communities.

Each of these disturbances to ecosystems, by itself, poses a serious threat of extinction to numerous plant and animal species. Yet none happens in isolation from the other forces that also imperil species, such as habitat destruction and fragmentation, the spread of invasive species and unsustainable harvest of resources for human consumption. Global warming combines with each of these non-climatic factors to place enormous stress on the planet's biological wealth.

If provided with sufficient funding, managers of wildlife, land and water have a number of tools at their disposal to ameliorate threats to ecosystems and to avert mass extinctions. Feasible actions include:

- *Maintaining healthy, connected, genetically diverse populations.* Small isolated populations are more prone to local extirpations than larger, more widespread populations. Although managers already encourage healthy populations, global warming increases the importance of this goal and will likely require adjustments in population targets and in the design of habitat corridors.
- *Reducing non-climate stressors on ecosystems.* Reducing other human-induced stressors such as toxic pollution and habitat loss will minimize negative synergistic impacts with global warming and increase the resiliency of habitats and species to the effects of climate change and variability.
- *Preventing and controlling invasive species.* Rapidly changing climates and habitats may increase opportunities for invasive species to spread. Extensive monitoring and control will be necessary to limit the negative impacts of invasive species.
- *Reducing the risk of catastrophic fires.* Global warming could lead to more frequent fires and/or a greater probability of catastrophic fires. Managers can use prescribed fires and other techniques to reduce fuel load and the potential for catastrophic fires.
- *Protecting coastal wetlands and accommodating sea level rise.* Managers can defend against the negative impacts associated with sea level rise through conservation easements and the acquisition of inland buffer zones to provide an opportunity for wildlife to migrate inland.
- *Adjusting yield and harvest models.* As fish and wildlife populations respond both directly and indirectly to climate through changes in hahitats, their productivity and sustainability may increase or decrease. Managers may need to adapt yield and harvest regulations both in anticipation and response to these changes.
- *Considering global warming models as well as historical data when making projections.* Managers must be aware that historical climate, habitat and wildlife conditions are not indicative of future conditions. Projections and planning should take into account expected changes in climate.
- *Employing monitoring and adaptive management.* Due to uncertainty concerning global warming, wildlife managers must anticipate the impacts to wildlife and use monitoring data to quickly adjust management techniques and strategies. Traditional, long-practiced methods and strategies will not be as effective as conditions change.
- *Identifying new opportunities.* Managers must be ready to anticipate and take advantage of new opportunities. For example, if climatic conditions leave existing agricultural areas unusable for agriculture, they could become important wildlife conservation areas with the appropriate agency and landowner collaboration.

Each of these essential steps comes with a price tag. Inevitably, managers of the nation's wildlife, land and water resources will need billions of dollars annually to develop and implement science-based strategies for conserving wildlife and ecosystems threatened by global warming. To make this conservation work feasible, Congress should ensure that substantial revenues generated hy any climate change legislation be dedicated to conserving the wildlife and ecosystems that would otherwise be lost or badly degraded by global warming.

We thank you for your consideration of this urgent matter.

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Requesting Adequate Funding for Wildlife and Ecosystems Threatened by Global Warming

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Responses by Larry J. Schweiger to Follow-Up Questions
Environment and Public Works Committee
October 29, 2009

Questions from Senator James M. Inhofe

1. *You state that the IPCC concluded that as many as a million species of plants and animals could be threatened with extinction between now and 2050 (40 years). How many species have gone extinct because of warming during the course of the 20th century?*

To our knowledge, no comprehensive study has attempted to examine the contribution of global warming to recent extinctions. In any case, one must look forward to fully understand the connection between human-caused global warming and species extinctions. Based on a review of multiple scientific studies looking at known risk factors for species extinctions and models of future conditions, the IPCC estimates that on average 20% to 30% of species assessed are likely to be at increasingly high risk of extinction from climate change impacts within this century as global mean temperatures exceed 2°C to 3°C relative to pre-industrial levels (IPCC 2007). The IPCC further found that if global average temperature were to exceed 4°C above pre-industrial levels, model projections suggest even more significant extinctions (40-70% of species assessed) around the globe. Climate change increases extinction risk in multiple ways, principally through causing changes to or deterioration of the habitats to which individual species have evolved and are adapted. Changes in temperature, precipitation and other climatic factors exacerbate or amplify other extinction risk factors, such as degradation and loss of habitat, spread of harmful invasive species, and spread of diseases.

2. *Ecosystems have been changing for millions of years, without human influence. Suppose some of this warming is natural. How do we conclude what ecosystem changes are natural and what are induced by human action?*

The IPCC (Working Group I Summary for Policy Makers) stated that "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." Scientists have closely studied other factors (e.g., variation in earth orbit, solar activity) that have historically caused global warming and determined that these are not significant factors in the current rapid global warming. The current rapid global warming is interacting with habitat destruction and fragmentation, the spread of harmful invasive species and other human actions to cause profound ecosystem change. This ecosystem change cannot be attributed to natural warming.

3. *You mentioned lengthening of the frost-free season and earlier date of the last spring freeze. Will some of the ecosystem changes be beneficial? For example, would we experience longer growing seasons in farming regions and an overall increase in areas that can be farmed due to a more suitable climate?*

The impact of climate change on crops and ecosystems is much more complicated than a longer growing season. While some plant species may benefit from a longer frost-free season, many will struggle to adapt to the multiple changes in temperature and precipitation they face. The *Global Climate Change Impacts in the United States* report, released by the U.S. Global Change Research Program in June 2009, has a chapter on Agriculture that provides a good summary. Here are the key messages from that chapter:

- Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields.
- Extreme events such as heavy downpours and droughts are likely to reduce crop yields because excesses or deficits of water have negative impacts on plant growth.
- Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control.
- Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed.
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

Warmer temperatures are detrimental to many crops that require cold temperatures to thrive. According to the same report, "common snap beans show substantial yield reduction when nighttime temperatures exceed 80°F" and "many varieties of fruits (such as popular varieties of apples and berries) require between 400 and 1,800 cumulative hours below 45°F each winter to produce abundant yields the following summer and fall." California could see losses of up to 40 percent for grapes, almonds, oranges, walnuts, and avocadoes due to warmer temperatures.

While global warming may make some areas more suitable for agriculture, other areas will be less suitable. For example, Iowa, where 2.5 billion bushels of corn were harvested in 2007, is projected to have a climate like that of western Oklahoma—much hotter and drier than it is today—if no steps are taken to reduce CO_2 emissions. This means that it will be much more difficult if not impossible to grow corn in Iowa.

Global warming is also reducing water availability and increasing drought stress in many croplands. This is a huge challenge for highly irrigated croplands, especially those that depend on winter snow pack. For example, spring snow pack in the Sierra Nevada, which provides critically important irrigation water throughout the summer, is projected to decline by 70 to 90 percent by 2100.

4. *Has the total number of Polar Bears in the wild decreased over the past 5 years?*

Polar bears live in extreme conditions and with home ranges often exceeding 200,000 km^2. (Mauritzen, M., et al. 2001. Space-use strategies of female polar bears in a dynamic sea ice habitat. Canadian Journal of Zoology; Sep2001, Vol. 79 Issue 9, p.1704.) Population sizes are therefore difficult to ascertain. Nonetheless, a decline in the population of polar bears in western Hudson Bay has been demonstrated to be caused by the decline in sea ice extent brought on by global warming (Regehr, E.V., Lunn, N.J., Amstrup, S.C., Stirling, I., 2007. Survival and population size of polar bears in western Hudson Bay in relation to earlier sea ice breakup. J. Wildl. Manage. 71, 2673–2683.) In 2005, "scientists and managers from the five Arctic nations with polar bears unanimously agreed to a status report that concluded that of the 13 populations within Canada, or shared with Greenland, two were severely depleted from previous overharvesting and were being managed for recovery, five were declining, and the rest were recorded as stable, except for one which was reported as increasing based on a computer projection model." (Sterling and Derocher, 2007. Melting Under Pressure – The real scoop on climate warming and polar bears. The Wildlife Professional (Fall, 2007)).

The extreme dependence of polar bears on Arctic ice extent and duration allows for projection of polar bear well-being based on Arctic ice trends. Stirling, I. and A.E. Derocher (ibid) report that "Superficially, polar bears might appear secure" and then go on to say that "...if the climate continues to warm and negatively affect the duration, extent, and thickness of arctic sea ice as predicted, it will ultimately have a negative effect on all populations." Since making that statement, Arctic sea ice decline has proceeded much more rapidly than projected. (Arctic sea ice decline: Faster than forecast. Julienne Stroeve,1 Marika M. Holland,2 Walt Meier,1 Ted Scambos,1 and Mark Serreze1 Received 15 February 2007; accepted 26 March 2007; published 1 May 2007.).

5. *Have forests in the eastern part of the country grown in size and density? And, with more carbon dioxide in the atmosphere, doesn't that make plants, specifically trees, use water more efficiently?*

In 2006, there were nearly 750 million acres of forest in the United States. (Heinz Center, State of the Nation's Ecosystems, 2008.) Forest in the eastern part of the country covers about 171 million acres in the North and 214 million acres in the South. Since 1953, forest area for the nation as a whole has not changed significantly (less than 1%). Forest lands in the South have decreased in area significantly, while forests in the North have increased.

The relationship between carbon dioxide concentrations in the atmosphere and tree growth and water utilization is complex. While elevated levels of carbon dioxide can have a stimulatory effect on tree growth, absence of carbon dioxide generally is not the limiting growth factor (Monje and Bugabee 1998). Experiments show that trees put most added carbon into producing fine roots and twigs, rather than new wood (Ryan et al 2008). The U.S. Global Change Research Program has concluded that "the effect of carbon dioxide in increasing growth thus seems to be relatively modest, and generally is seen most strongly in young forests on fertile soils where there is also sufficient water to sustain this growth." Where such increases exist, however, they may be offset by other climate-related changes affecting these forests, including increased variability in precipitation, the spread of invasive species, and increases in forest pests. Indeed, experimental carbon dioxide enrichment experiments demonstrate the differential advantages of elevated carbon dioxide levels for certain weedy species, such as poison oak vines, which can have detrimental effects on forest and human health (Mohan et al. 2006).

On the issue of water efficiency in trees, the interactions between carbon dioxide and water availability on plant hydraulics are still poorly understood (Domec et al. 2009). Indeed, there are contradictory published results on this topic, based in part on the types of trees evaluated (broadleaf vs. conifer) and the experimental approaches used. Accordingly, the generalized assertion that elevated carbon dioxide levels enable trees to use water more efficiently is not supported by the available scientific literature.

6. *You mention potential short-term financial hardship that could result from a program to reduce global warming. What form would "financial hardship" take? Higher gasoline prices? Higher food prices? Fewer jobs? Please provide greater details about "financial hardship."*

As shown by the October 23, 2009, EPA report on the Clean Energy Jobs and American Power Act, a global warming pollution reduction program that includes a "polluter pays" funding mechanism and that returns a substantial portion of allowance value to consumers imposes no financial hardship on lower-income consumers. Although higher-income consumers are anticipated to experience modest increases in electricity rates, these costs are far less than the costs that these consumers would bear if Congress were to fail to enact a cap on global warming pollution. Moreover, the Clean Energy Jobs and American Power Act provides a wide array of benefits that must be factored into any cost-benefit analysis, including the enormous financial and job-stimulating benefits of energy efficiency and other clean energy measures and the economic and quality-of-life benefits of conserving threatened species and ecosystems.

Question from Senator George V. Voinovich

1. Based on your testimony, it isn't it clear to me how much of the natural resource adaptation funding from this bill should go to the Great Lakes. Do you have a recommendation?

The National Wildlife Federation is pleased that the Clean Energy Jobs and American Power Act provides dedicated funding for safeguarding the Great Lakes and other ecosystems threatened by climate change. We estimate that under the bill's allocation of allowance value, an average of roughly $1.4 billion will be made available annually for such natural resources adaptation work over the first 19 years, helping to boost the economies and quality of life of communities across the country. Although the costs of safeguarding ecosystems threatened by climate change is substantially greater than this, such an allocation represents an important down-payment on long overdue bills.

Although the Clean Energy Jobs and American Power Act specifies how allowance value will be allocated among various federal and state natural resources agencies, it does not specify how this value will be further allocated to the Great Lakes and other ecosystems. We support the bill's approach of allowing the agencies to determine how to allocate resources among ecosystems within their jurisdictional areas.

Senator BOXER. Thank you. Thirteen thousand people on one phone call with Senator Warner.

Mr. SCHWEIGER. We had 11,000 on another with Ted Roosevelt.

Senator BOXER. It is extremely impressive.

I want to make sure I pronounce our next witness's tribe in the right way here. Fawn Sharp is easy to say. But is it Quinault?

Ms. SHARP. Yes, it is Quinault. It is also pronounced in French as Quinault. There is a Quinault wine. But we pronounce it Quinault.

Senator BOXER. Quinault Indian Nation.

Ms. SHARP. Yes.

Senator BOXER. From Washington State, is that correct?

Ms. SHARP. That is correct.

Senator BOXER. Welcome.

STATEMENT OF FAWN SHARP, PRESIDENT, QUINAULT INDIAN NATION

Ms. SHARP. Thank you. I thought you were going to ask about my name pronunciation. I do want to comment, with regard to Senator Whitehouse, I was introduced by a Narragansett official last week and he pronounced my name Fawn Shop.

[Laughter.]

Senator WHITEHOUSE. You know, that is not bad for Rhode Island.

[Laughter.]

Ms. SHARP. Thank you. Senator Boxer, Senator Inhofe and members of the committee, I am truly honored, indeed, to present testimony on behalf of the Quinault Indian Nation. The Quinault Indian Nation truly appreciates the committee's efforts and dedication. My testimony was prepared in consultation with several of the tribal organizations and tribes throughout the United States, including the National Congress of American Indians.

We applaud the committee for expanding this bill to include important tribal provisions that were not in the House bill, H.R. 2454, namely, inclusion of the BIA funding as an eligible purpose of Department of the Interior natural resources adaptation funding, an extra alternative funding possibility for natural resources adaptation on tribal lands, as well as inclusion of tribal land as an eligible recipient of funds under the Supplemental Agricultural Reductions Program which significantly increase and extend it from 0.25 percent for 2 years to 1 percent throughout the life of the bill, and finally, the required consultation with the Secretary of the Interior when EPA determines the tribal set-asides.

I have also reviewed the adaptation provisions of the recently released Chairman's proposed amendment to the bill and express overwhelming appreciation and support for these additional provisions that were not included in the original version. I have identified them in more detail in the expanded version of my testimony that has been submitted for the record.

Senator BOXER. We will put that in.

Ms. SHARP. Today, we urge congressional leadership to move forward with legislation to help the United States prepare and adapt for the challenges of climate change and to attain the goals of energy independence and security. We look forward to working with

Congress and the Administration in the development of climate change legislation to ensure that tribal needs and concerns are adequately addressed.

I begin my remarks by stating a very important fact. Indigenous peoples, including American Indians, Alaskan Natives and Hawaiian Natives are among the most vulnerable to the impacts of climate change in the world. This fact is recognized by the Intergovernmental Panel on Climate Change.

In the United States, according to the GAO office, 86 percent of Alaskan Native Villages are threatened by flooding and erosion because of warming temperatures. Thirty-one villages are imminently threatened, and 12 villages have opted to relocate permanently.

Since 1928, my neighbor to the North, the Hoh Tribe, has been plagued with flooding every 10 years. The result is severe soil erosion that has reduced the reservation from 443 acres to 400 acres. For more than a decade, the Hoh Tribe has been aggressive in its efforts to get the reservation relocated before extreme river flows and increases in sea level completely wash the land, the people and the future of the Hoh Tribe into the ocean.

At home, the Quinault Indian Nation is proactively addressing the uncertainties and impacts of climate change by developing risk assessment, adaptation, and mitigation plans by July 2010.

During my first year as tribal President, I was confronted face-to-face with impacts of climate change. I received an urgent call from our scientists who had discovered massive dead fish washed ashore our pristine coastline. This was known as the Dead Zone. It affected the entire West Coast of Washington and the shores of Oregon. The shore was riddled with dead fish from every spectrum of the food chain. It was not a singular fish.

In the last year, actually, earlier this month, I took a helicopter flight over the Anderson Glacier. This glacier, which feeds the Quinault River, is one of four. We have been monitoring this glacier quite closely over the last 20 years. The University of Washington has photos and has been monitoring it since the turn of the century.

In the last 20 years, we noticed that it receded 1,700 feet. When I took the flight earlier this month, the entire glacier is gone. It disappeared.

We are heartened that the Senate and House committees have recognized the nation-to-nation relationship between the Federal Government and tribes by including us in many critical provisions like renewable energy, domestic adaptation and natural resources adaptation.

We seek to be sovereign partners in the climate change programs. We seek equitable shares of the allocations provided to States and tribes.

Finally, I have two other recommendations that I would like to note in my remarks. We ask that the committee direct the GAO to prepare a report on climate change and tribal nations in the Lower 48. There have been two GAO reports on the impacts of climate change to Alaska native villages, once in 2003 and once in 2009. A report on climate change and tribal nations in the Lower 48 would document for Congress and the Administration the widespread cloud of destruction that awaits our reservations, our people and our livelihood.

Last, section 372, the Additional Provisions Regarding Indian Tribes, we ask that contain a disclaimer to protect treaty and other federally reserved tribal rights.

Thank you.

[The prepared statement of Ms. Sharp follows:]

Quinault Indian Nation

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Testimony Presented by President Fawn Sharp, Quinault Indian Nation at the Legislative Hearing on S. 1733, Clean Energy Jobs and American Power Act before the Senate Committee on Environment and Public Works

October 28, 2009
Washington, D.C.

Oral Testimony

Senator Boxer, Senator Inhofe and members of the Senate Committee on Environment and Public Works, it gives me great pleasure to present testimony today on behalf of the Quinault government. The Quinault Indian Nation greatly appreciates the efforts of the Committee. My testimony was prepared after consultation with several tribes and organizations, including the National Congress of American Indians.

I applaud the Committee for expanding S. 1733 to include important tribal provisions that were not in the House bill, H.R. 2454:

1. Inclusion of Bureau of Indian Affairs (BIA) funding as an eligible purpose of Department of the Interior (DOI) natural resources adaptation funding, an extra, alternative funding possibility for natural resources adaptation on the lands of Indian tribes

2. Inclusion of tribal land as an eligible recipient of funds under the Supplemental Agricultural reductions program which significantly increased and extended funding from 0.25% for 2 years to 1% or greater for the life of this bill

3. Require consultation with the Secretary of the Interior when the Environmental Protection Agency (EPA) determines the tribal set-asides

I have reviewed the adaptation provisions of the recently released Chairman's proposed amendment to S. 1733 and express overwhelming appreciation and support for these additional provisions that were not included in the original version of S. 1733. I have identified them in more detail in the expanded version of my testimony for the record.

We urge Congressional leadership to move forward with legislation to help the United States prepare and adapt for the challenges of climate change and attain goals of energy independence and security. We look forward to working with Congress and the Administration in the development of climate change legislation to ensure that tribal needs and concerns are adequately addressed.

1. Indigenous peoples, including American Indians, Alaska Natives, and Hawaiian Natives, are among the most vulnerable to the adverse effects of climate change in the world.

This fact is recognized by the Intergovernmental Panel on Climate Change. In the United States, according to the General Accountability Office, eighty-six percent of Alaska Native Villages are threatened by flooding and erosion because of warming temperatures, 31 villages are imminently threatened, and 12 villages have opted to relocate permanently. A few years ago, several Indian Tribes in southeast Louisiana were devastated by hurricanes Katrina and Rita. Tribal communities in this country are becoming climate change refugees.

Since 1928, my neighbor to the North, the Hoh Tribe, has been plagued with flooding every ten years. The result is severe soil erosion that has reduced the reservation from 443 acres to 400 acres; the loss of approximately 800 feet of tribal lands along an 1800-feet stretch of the Hoh River. For more than a decade the Hoh Tribe has been aggressive in efforts to get the reservation relocated before extreme river flows, increases in sea level, or a tsunami completely wash the land, the people and the future of the Hoh Tribe into the ocean.

2. The Quinault Nation is proactively addressing the uncertainties and impacts of climate change by developing risk assessment, preparation, adaptation, and mitigation plans by July of 2010.

These plans are to identify and prioritize the values to be protected, using a combination of western science and traditional knowledge. Natural resources, our fish, forests, wildlife, and water are vital to our culture, economy, and continuity as a community. We rely upon these resources to provide employment, economic opportunity, income, foods, and medicines.

Because of chronic underfunding of our natural resources programs, our ability to prepare and mitigate for effects of climate change is extremely limited. Despite these challenges, we have cobbled together staff, resources and partners to undertake critical projects. We recently completed the first phase of a long-term adaptation project to restore ecosystem functions in the Upper Quinault River through the installation of engineered log jams in collaboration with the National Park Service, Forest Service, local property owners, and others. The project was designed to stabilize water flows and channel structure from extreme flows, provide spawning and rearing habitat for salmon, and protect roads and property from excessive erosion. It will require several years and millions of dollars to complete; thankfully, members of the Administration and Congress have been very supportive. The Quinault Nation assigned this long-term, expensive, project a high priority to protect our Blueback (a unique run of sockeye). The Blueback has sustained our culture and economy for millennia. Quinault Nation and other tribes are capable stewards whose initiatives can be multiplied with federal support in climate change legislation.

3. We are heartened that the Senate and House climate change bills – the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act – have recognized the nation-to-nation relationship between the federal government and tribes, by including us in many critical provisions, like renewable energy, domestic adaptation, and natural resources adaptation.

We seek to be sovereign partners in climate change programs. We seek equitable shares of the allocations provided to states and tribes for the provisions relating to renewable energy, energy efficiency, domestic adaptation, and natural resources adaptation.

The Chairman's mark and the original Senate bill provide 3% of the natural resources adaptation fund to tribes. This will not adequately or equitably provide for tribal needs nor recognize the importance of natural resources to this nation. The overall allocation for natural resources adaptation should be significantly increased. I suggest that tribes receive more than 5% of the allocation provided to states and tribes for renewable energy, energy efficiency, domestic adaptation, and natural resources adaptation, given that tribal infrastructures and natural resources are disproportionately impacted by climate change. Tribal lands hold vast renewable energy potential, yet tribal governments are provided very little federal support for those efforts particularly compared to states. Furthermore, since the federal government recognizes that Indian Country has a housing shortfall of 200,000 homes, that an acre of Indian forest land receives one-fourth the per-acre funding of national forests, and only a handful of the 564 federally recognized tribes are engaged in adaptation planning, compared to over 60% of states, we believe our requests are reasonable.

5. The Committee should direct the Government Accountability Office (GAO) to prepare a report on "Climate Change and Tribal Nations in the Lower 48".

There have been two GAO reports on the impacts of climate change to Alaska Native Villages, once in 2003 and again in 2009. A report on climate change and tribal nations in the lower 48 would document for Congress and the Administration the widespread cloud of destruction that awaits our reservations, our people and our livelihood.

6. Section 372, "Additional Provisions Regarding Indian Tribes", should contain a disclaimer to protect treaty and other federally-reserved tribal rights.

Section 372(a) Pertains to the Federal Trust Responsibility. However, this is not a customary tribal savings provision. Customary tribal saving provisions directly safeguard tribal rights from potential diminution by federal statutes.

* * *

I appreciate the opportunity to testify before this committee and request that the record be left open for a length of time so that we may address the legislation provisions in detail. Thank you.

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Environment and Public Works Committee Hearing
On S. 1733, "Clean Energy Jobs and American Power Act"
October 28, 2009
Follow-Up Questions for Written Submission
Questions for Fawn Sharp, President, Quinault Indian Nation

Questions from:
Senator Barbara Boxer

1. President Sharp, are there additional issues that are relevant to your tribe from your testimony that you would like to elaborate on for the record?

Response: The Quinault Nation is pleased to submit the attached additional statement which expands upon the points summarized in oral testimony presented at the hearing on October 28.

Additional Issues and Comments by Fawn Sharp, President, QIN 28 October 2009
On S. 1733, Clean Energy Jobs and American Power Act

I also am pleased to note that the Chairman's mark includes tribal provisions that were not contained in the original version of S.1733:

1. Tribal consultation requirements in clean transportation planning provisions (Title 1, Part C)

2. Indian Housing has been included in the energy efficiency retrofit program (Title 1, Part E, Sec. 164)

3. Tribal coordination is required in state natural resource adaptation planning (Sec. 369)

4. BIA's Trust Natural Resources Program is included as an eligible program for tribal natural resources adaptation funding, in addition to Fish Wildlife Service's (FWS) Tribal Wildlife Grants Program (TWGP)(Sec. 370)

5. Tribes are included in the natural resources fish and wildlife habitats and corridors planning provisions (Sec. 371)

6. Tribal rights to protect First Foods (Sec. 372)

7. Tribes are included in drinking water and wastewater system adaptation provisions (Sec. 381)

8. Tribal coordination is included in the coastal and Great Lakes adaptation provisions (Sec. 382(d)(3))

9. Tribal authority in electric utility law and regulation is preserved in savings clause (Sec. 721(d))

10. Tribal set-aside for home heating oil and propane consumers, to be determined by regulation (Sec. 774(f)).

11. Changed the set-aside in the State Energy and Environment Development (SEED) account (energy efficiency and renewable) from 1% to 1-3%. (This is important because it recognizes the large amounts of renewable energy resources that belong to tribes.)

12. Increased the tribal set-aside for state (i.e. human) adaptation from 1% to 1-5%. This is especially important because it recognizes the significant impacts of climate change on tribal communities.

My testimony is favorable toward S. 1733, *Clean Energy Jobs and American Power Act.* I note that the draft goes some distance to include Indian governments in state, regional and federal decision-making bodies. I urge the Committee to recognize, however, that the process for ensuring full Tribal participation must take into consideration the need to recognize the right of each Tribal community to make its own decisions based on information they have gathered themselves as well as information provided through mechanisms established in U.S. law. These provisions have special relevance when considering S. 1733.

Additional Issues and Comments by Fawn Sharp, President, QIN 28 October 2009
On S. 1733, Clean Energy Jobs and American Power Act

Subtitle E—Miscellaneous (section: 155, 156 and 157) Subtitle F—Energy Efficiency and Renewable Energy, Subtitle H—Clean Energy and Natural Gas, Subtitle B—International Climate Change Programs, Part E—Supplemental Emission Reductions *(Sections 751-752) and* **Subtitle C—Adapting to Climate Change.**

Strengths of S. 1733

S. 1733 takes important steps toward controlling carbon dioxide and greenhouse gases (GHG) for the first time since the government began working to clean the environment and established the Environmental Protection Agency in 1970.

The Senate measure contains quite a number of improvements over the House version. The subpart (i) **State and Tribal Climate Change Response Plans** encourages Tribal and state cooperation in the development of climate change responses and in particular gives latitude for specific Tribal geographic, human and ecologic circumstances when it states that Tribal plans: "... may vary from those of State climate change response plans to the extent necessary to account for the special circumstances of Indian tribes." Indian reservations contain one or more specific ecological niches that are quite different from neighboring areas or other areas of the state and places an Indian government in the unique position of having the proximate knowledge to best respond to specific affects of climate changes.

Weakness in S. 1733

American Indian and Alaskan Native concerns cut across virtually all sections of S. 1733. Some of these concerns apply to both S.1733 and H.R. 2454 (Attachment B).

Many Indian nations are forest dependent and consequently must be considered an essential part of the process of reducing carbon releases into the environment. S. 1733 does not fully respond to the important pressures reduced timber cuts will place on timber dependent nations. While there is attention to the reduction of deforestation in developing countries and indigenous peoples dependent on those forests, there is no equivalent consideration of forest dependent sovereign nations in the United States. S. 1733 will benefit from such consideration.

Tribal Culture is given weight in S. 1733 and I believe it should have greater weight when we consider the formulation of regulations and standards for responses to adaptation needs.

Recommended Changes to S. 1733

S. 1733 Recommendation: A 5 percent set-aside for Indian tribes to carry out natural resources adaptation activities, with ½ available through the BIA Trust Natural Resources Program, ¼ available through the U.S. Fish and Wildlife Service Tribal Wildlife Grants Program, and ¼ available through the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service Program.

Additional Issues and Comments by Fawn Sharp, President, QIN 28 October 2009
On S. 1733, Clean Energy Jobs and American Power Act

The recommended increase in resources for Indian tribes to undertake natural resource adaptation activities, namely from 3 to 5 percent, is to more accurately reflect the land base and population of tribes, the high value of undisturbed habitat existing in Indian Country, the high value of Indian Country habitat for wildlife, the historical lack of federal financial support for tribal conservation and climate adaptation, and the significant need for tribes to build capacity for climate adaptation. A distribution of the 5 percent among several federal programs for tribes is suggested because there is a significant need for consistent and stable funding for tribal adaptation activities. Housing the entire 5 percent under the FWS Tribal Wildlife Grants Program would make the funds subject to a competitive program involving the 564 federally recognized tribes. As a result, only some tribes would receive funding with the consistency of such funding from year to year dependent upon the award of grants. In addition, the TWG program uses a portion of the funds for FWS administrative costs which reduces the amount available to tribes. The U.S. Department of Agriculture-Natural Resources Conservation Service Program for American Indians and Alaska Natives is a suggested program for distribution of a portion of the 5 percent because the program provides valuable assistance to tribal conservation efforts, particularly to Alaska Natives and would be a valuable source for climate adaptation activities. The Bureau of Indian Affairs Trust Natural Resources Program is a suggested program for distribution of a portion of the 5 percent because the program currently provides funds to tribes for conservation and natural resource management work in the areas of fisheries, wildlife, water, forestry, agriculture, and other tribal natural resource activities. In addition, the BIA program would be an efficient distributor of funds because tribes have self-governance compacts, self-determination and/or 638 contracts with the BIA, which streamlines and makes efficient the distribution of funds.

S. 1733 Recommendation: The 17 percent allocation to the Department of the Interior for natural resource adaptation activities should be apportioned and distributed on an equitable basis based upon land ownership and management, including 16.02 percent of the allocation to Indian tribes in accordance with their responsibility for 95 million acres.

While S. 1733 provides a 17% allocation for use by the National Park Service (NPS), U.S. Fish and Wildlife Service, Bureau of Land Management (BLM), and Bureau of Indian Affairs, the Act does not provide any clarity on how the 17% would be apportioned. In light of the historical inequity of federal funding to Indian tribes for natural resources, it is critical that S. 1733 ensures that tribes receive an equitable share of the allocation. Tribes have treaty rights to own and manage 95 million acres of land in the United States, as well as have treaty rights to Traditional and Accustomed Areas outside the boundaries of Indian reservations. On the 95 million acres for which tribes have ownership and management as well as treaty rights, Indian tribes have both sovereign authority and the responsibility to manage the natural resources, wildlife, and other ecological resources. Thus, at a minimum, tribes should receive an allocation of the funds intended for natural resource adaptation activities in proportion to the lands for which they both have treaty rights and ownership and management. Accordingly, it is important that the funds available for use by the National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and Bureau of Indian Affairs be allocated under a formula that provides tribes with an allocation that, at a minimum, reflects the amount of land for which they have treaty rights and ownership and management (see Attachment A).

Additional Issues and Comments by Fawn Sharp, President, QIN 28 October 2009
On S. 1733, Clean Energy Jobs and American Power Act

S. 1733 Recommendation: Flexibility and equity must be ensured in the apportionment and distribution of the Land and Water Conservation Fund (LWCF) made available on a competitive basis to Indian tribes and States by conducting consultation among the DOI, USDA, Indian tribes, and States. This will be ensured by determining apportionment and distribution via consultation and coordination among the Secretary of the Interior, Secretary of Agriculture, Indian tribes, and States in accordance with Executive Order 13175 of November 6, 2000 – Consultation and Coordination With Indian Tribal Governments.

While Indian tribes support providing 1/3 of the Land and Water Conservation Fund (1/6 through the Interior Department plus 1/6 through the Agriculture Department) on a competitive basis to states and Indian tribes to carry out adaptation activities through the acquisition of land and interests in land under section 6 of the LWCF, there is a legitimate concern among tribal leaders that restricting those funds to acquisition of land limits the potential adaptation activities that could be carried out by their respective tribes. It is therefore recommended that more flexibility be built into the use of LWCF monies by adding "and other activities" to the language. In addition, making LWCF monies available to States and Indian tribes on a competitive basis provides no guarantee that the nation's more than 560 tribes would receive an equitable share. Thus, it is recommended that apportionment and distribution of funds would be determined in consultation among the Interior/Agriculture Departments, Indian tribes, and States.

S. 1733 Recommendation: Provisions must be made for taking tribal traditional knowledge into account, consistent with tribal concerns over confidentiality and protection of their rights to such knowledge. Wherever S. 1733 makes a reference to the use of the "best available science" or "scientific knowledge" or to the collection or evaluation of information or data, scientific or otherwise, the reference should also include tribal and other indigenous peoples' traditional knowledge. Provided, however, that such knowledge must be protected from misappropriation and can only be accessed and used with the free, prior, and informed consent of the tribe or other indigenous peoples involved.

Traditional systems of knowledge are grounded in cultural ways that have evolved over many lifetimes. Native science is demonstrated through the test of time long preceding the existence of the United States to favorably maintain a balance between human needs and the capacity of nature to meet them. Each tribal community remains rooted in traditional systems of knowledge and native sciences that must become a co-equal influence in decisions concerning policy and regulations addressing mitigation and adaptation to the adverse effects of climate change. Native science and conventional science together enhance human capacity to effectively address changing climate.

Climate legislation must acknowledge the importance of tribal traditional knowledge in assessing and addressing climate change, and must adopt measures to protect that knowledge. Tribal traditional knowledge has many dimensions of spirituality, sacredness and cultural privacy. In many cases, the appropriate relationship will require that traditional knowledge be used in a co-management context and not shared with federal agencies. Traditional adaptation technologies and genetic resources for agricultural adaptation may have significant commercial value, and should be protected from misappropriation and accessed only under the principle of free, prior and informed consent as agreed to in the Convention on Biological Diversity (CBD) and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP, 2007).

S. 1733 Recommendation: We are pleased to note that the Chairman's proposed amendment to S.1733 released this past Friday protects Indian tribes' rights to First Foods. Consistent with the Natural Resources Climate Change Adaptation Policy under Section 472 and the Natural Resources Climate Change Adaptation Strategy under Section 476, Federal departments and agencies, States, and Indian tribes will ensure communication and coordination to protect Indian tribes' treaty-reserved gathering rights of First Foods, with the term First Foods meaning roots, berries, and plants.

Climate change potentially has serious adverse effects on the abundance, quality and availability of living resources that tribes reserved to sustain their cultures through species range shifts, extirpation, extinction and ecological change. Particular attention should be given to ensuring continued tribal access to first foods, traditional medicines, ceremonial and ritual species, and other species required by tribes to sustain their cultures, health, well-being, identities and economies.

Request Opportunity to Supplement Comments

Since S.1733 is still under development and I have not been able to review the complete proposed amendment released on October 23rd, I request that the Committee's record remain open to afford the opportunity to provide additional comments after the hearing and with further in-depth review of legislative proposals.

Impacts of Climate Change on American Indians

Indigenous peoples, including American Indians, Alaska Natives, and Hawaiian Natives, are among the most vulnerable to the adverse effects of climate change in the world. This fact is recognized by the Intergovernmental Panel on Climate Change. In the United States, according to the General Accounting Office, eighty-six percent of Alaska Native Villages are threatened by flooding and erosion because of warming temperatures and 31 villages are imminently threatened, and 12 villages have opted to relocate permanently. A few years ago, several Indian Tribes in southeast Louisiana were devastated by hurricanes Katrina and Rita including United Houma Nation, the Pointe-au-Chien Tribe, the Isle de Jean Charles Indian Band of Biloxi-Chitimasha, the Grand Caillou-Dulac Band and the Biloxi-Chitimasha Confederation of Muskogees. Tribal communities in this country are becoming climate change refugees.

Since 1928, my neighbor to the North the Hoh Tribe has been plagued with flooding every ten years. The result is severe soil erosion that has reduced the reservation from 443 acres to 400 acres; the loss of approximately 800 feet of tribal lands along an 1800-feet stretch of the Hoh River. For more than a decade the Hoh Tribe has been aggressive in efforts to get the reservation relocated before extreme river flows, increases in sea level, or a tsunami completely washes the land, the people and the future of the Hoh Tribe into the ocean.

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The homelands of all Tribes that live in lowlands near the oceans and rivers will suffer from rising sea levels, increasing acidification, and extreme weather and water flows expected to result from climate change. In the southwest and plains states, Tribes will need to contend with problems from drought and water supplies. Long neglected housing, energy efficiency, sanitation, education, public safety, and employment needs can be expected to become even worse as climate change affects our communities. The fish, wildlife, foods, and medicines that our communities still rely upon will be affected. For example, tribes heavily dependent on fish for economic and cultural vitality are facing a substantial loss of salmon and trout habitat across the U.S. in the next 40 to 80 years.

On a flight early in October to inspect the status of the glaciers in the Quinault and Queets river systems, I was dismayed to see the demise of Anderson Glacier, the source of the Quinault River and clean, cool water required to sustain the Chinook salmon that return to our rivers in the springtime. We have watched for a number of years the rapid retreat of this glacier, but its quick end still comes as a shock. The other glaciers in both river watersheds are also in retreat and many areas once covered by permanent snowfields are bare. Our forests are threatened with catastrophic loss from drought, wildfires, insects, and disease. The fresh water that serves as the life-blood of Tribal communities is becoming increasingly scarce and polluted.

The Quinault Nation has undertaken an initiative to proactively deal with prospective uncertainties and impacts of climate change by developing risk assessment, preparation, adaptation, and mitigation plans by July of 2010. These plans are to identify and prioritize the values to be protected, using a combination of western science and traditional knowledge. Natural resources, our fish, forests, wildlife, and water are vital to our culture, economy, and continuity as a community. We rely upon these resources to provide employment, economic opportunity, income, foods, and medicines.

Because of chronic underfunding of our natural resource programs, our ability to prepare and mitigate for effects of climate change are extremely limited. We have had to take extraordinary efforts to cobble together staff and resources from many different sources to undertake critical projects. For example, we recently completed the first phase of a long-term project to restore ecosystem functions in the Upper Quinault River through the installation of engineered log jams through a cooperative effort with the National Park Service, Forest Service, local property owners, and others. The Quinault Nation assigned this long-term, expensive, project a high priority to protect our Blueback (a unique run of sockeye), which has sustained our culture and economy for millennia, from continued degradation of habitat from development and water flows that have become increasingly extreme in recent years. The project, designed to stabilize flows and channel structure from extreme flows, provides spawning and rearing habitat for salmon, and protects roads and property from excessive erosion, will require several years, and millions of dollars to complete. Thankfully, members of the Administration and Congress have been very supportive.

American Indians are now and have been for decades coping with the effects of changing climate. Our elders have warned for decades about the consequences of disrespect for Mother Earth. We witness first hand, the degradation of our lands, waters and resources. We have seen radical changes in the environment and the health of our peoples. We have seen increasing rates of chronic diseases as the United States has industrialized and produced greenhouse gases and toxins in the air, water and soils over the last 150 years. Our Tribal communities are not significant producers of carbon dioxide or greenhouse gasses, yet we must bear the consequences.

At the same time, tribal lands hold vast renewable energy potential, capable of providing a significant percentage of the nation's energy needs. The experience and traditional knowledge that has sustained our communities for thousands of years can and must inform research, planning, adaptation, and mitigation for climate change. Our traditional practices are inherently time-tested, climate resilient and sustainable. They must be accorded due recognition and support.

Tribal Support for Climate Change Legislation

Tribes have consistently sought legislative remedies through the U.S. Congress to address climate change trends, and frankly it has been a steep hill to climb. We are now eager to contribute to solutions in S. 1733 that are both comprehensive and responsive to the needs at the ground level where "Climate Change" is having the greatest impact.

We are heartened that the S. 1733 and H.R. 2454 have recognized the nation-to-nation relationship between the federal government and tribes, by including us in many critical provisions, like renewable energy, domestic adaptation, and natural resources adaptation. This is a good start to ensuring that Indian tribes are full and sovereign partners in the crafting and implementation of policies, standards, programs, and regulations. However, much more needs to be done; in recognition of the disproportionate impact climate change has upon us, the historical inequities in funding provided to tribes compared to states, our nation-to-nation relationship, and the federal government's trust responsibility to Indian tribes.

We seek to be meaningful partners in climate change programs. We seek equitable shares of the allocations provided to states and tribes for the provisions relating to renewable energy, energy efficiency, domestic adaptation, and natural resources adaptation. We ask that this funding account for the vast diversity of tribal circumstances, not only by supporting programs that provide on-the-ground solutions, but opportunities for tribes to build their institutional capacity.

For example I suggest that tribes deserve more than 1% of the allocation provided to states and tribes for renewable energy development for their peoples and the U.S. as a whole.

Wind and solar potential on tribal lands can provide a significant percentage of the nation's energy needs; yet, the Tribal Indian Energy Development and Self-Determination Act (Title V of the Energy Policy Act of 2005) has never been meaningfully funded, but $3.1 billion has been provided to States under the State Energy Program efficiency vast renewable energy potential on Indian lands. Over 11% of tribal homes have no access to electricity and the Recovery Act provided no direct funding to tribes for renewable energy projects. When we produce more energy than our communities require, we will access markets and electrical grids to help contribute to state and regional needs.

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I also suggest that tribes receive more than 5% of the allocation provided to states and tribes for domestic adaptation, and 5% of natural resources adaptation to enable disproportionate impacts of climate change on tribal infrastructures and natural resources. This is entirely reasonable and justified. The federal government has recognized that Indian Country has a housing shortfall of 200,000 homes. Indian forest land receives only a fourth of the per acre funding provided for national forests. Only a handful of the 564 federally recognized tribes are engaged in adaptation planning, compared to over 60% of states.

Climate change poses an imminent threat to tribal ways-of-life, which are dependent on the land, water, and wildlife that have been fundamental to tribes for thousands of years. Tribal life is intrinsically connected with the land and the living beings that reside on it. Tribal cultures are based around the preservation and use of the natural resources on which tribal communities depend.

Tribal livelihoods often depend directly on the natural resources that are being adversely impacted by climate change. Tribes whose cultures and economies rest on the availability of aquatic species such as salmon are seeing smaller populations every year. Prolonged droughts and intensified floods brought on by climate change are destroying riparian habitat, depleting food sources and eliminating fish spawning grounds. Coastal tribes that have depended on fishing for centuries are now facing an imminent challenge to their cultures and ways of life. As temperatures increase with climate change, our forests will become more vulnerable to catastrophic loss from wildfire, insects, and disease. Water for our communities and crops will become increasingly scarce and competition for limited supplies will become fiercer and more intense. The productivities, migration patterns, and ranges of wildlife, birds, and plants will be altered and our ability to adapt will be limited by the boundaries of our reservation lands. Climate change will affect nearly every aspect of our lifeways.

Few people realize the role American Indians and Alaska Natives have played in managing and protecting natural resources and wildlife. Thus, despite having some of the most pristine and undisturbed habitat in the United States, tribes have been historically underfunded for wildlife and natural resource conservation.

The lack of coordination by the federal government to develop a plan and preliminary strategy about climate change has impeded all tribal efforts to have a voice in the discussion and to participate in developing the agenda. I request that this Committee direct the Government Accountability Office (GAO) to prepare a report on "Climate Change and Tribal Nations in the Lower 48". There have been two GAO reports on the impacts of climate change to Alaska Native Villages, once in 2003 and again in 2009. Such a report would document for Congress and the Administration the widespread cloud of destruction that awaits our reservations, our people and our livelihood.

We urge you to facilitate and support an active role for tribes in shaping the future of our country. The experience and traditional knowledge that has sustained our communities for thousands of years can and must be valued as integral informed research, planning, adaptation, and mitigation for climate change.

Additional Issues and Comments by Fawn Sharp, President, QIN 28 October 2009
On S. 1733, Clean Energy Jobs and American Power Act

The federal government has a profound trust responsibility to act in the best interest of tribes, preserving the perpetual rights set forth in the treaties and other agreements that our ancestors signed. When our ancestors signed those treaties, the federal government was expected to honor its promises forever.

Confronting global warming requires not only the best available science, but should incorporate the traditional knowledge of the peoples who have had the longest relationship with America's natural resources. Traditional knowledge is the product of continuous practice over countless generations, developed through years of observation and experience, to balance the needs of the people with the capacity of the environment to meet them, and, to adapt to changing conditions.

We urge that you recognize the necessity for including American Indians, Alaska Natives and Hawaiian Natives, as full partners and essential sovereigns when crafting policies, standards, programs, and regulations. We urge you to facilitate and support an active role for tribes in shaping the future of our country. The experience and traditional knowledge that has sustained our communities for thousands of years can and must be valued as integral informed research, planning, adaptation, and mitigation for climate change.

We trust that the United States will respect our territorial sovereignty over our lands and resources, in accordance with nationally and internationally recognized rights of indigenous peoples in the United States and throughout the world. Tribal nations must be allowed to benefit directly and equitably from revenues generated by international, federal, regional, state or local efforts to control greenhouse gas emissions. Measures to control greenhouse gas emissions must be based on targeted reductions connected to causes and remedies for the effects of climate change, and not transfer costs to tribal communities in the United States or elsewhere. Tribal peoples, communities, lands and the resources on which we culturally, traditionally and economically depend must not be victimized in federal efforts to support renewable energy and energy efficiency.

We seek to share equitably in funding provided under climate legislation to enable our communities to plan, prepare, adapt, and mitigate for future effects of climate change. We want to help the United States contend with climate change at local, state, regional, federal and international levels and to contribute to the attainment of national goals for energy independence and security.

When considering legislation pertaining to climate, we urge that you take an approach that involves a comprehensive, integrated strategy to control accumulations of green house gases and includes measures to help meet national needs for energy independence and security. Development of clean, affordable energy and renewable fuels and programs to improve energy efficiencies will be vital to the future capacity of Tribes to cope with climate change.

I also urge this Committee to continue to invite active Tribal participation in future discussions and negotiations on S. 1733 to ensure full and comprehensive coverage of our social, economic, political and cultural interests. We further ask Congress to provide direct technical and financial support to Tribal governments to enable full tribal participation in the development of policies and standards, preparation of plans, and operation of programs to help tribal and other native communities cope with climate change. Such support is necessary also to ensure that our nations benefit from opportunities to participate in emerging markets for clean, renewable energy.

S. 1733 must be both responsive to deal with immediate affects of climate change and it must be proactive to address longer-term threats to Tribal peoples and communities. Tribal priorities for climate legislation developed by a consortium of Tribal governments and organizations are attached to my testimony for your consideration and reference. I have highlighted some key areas and provided suggestions for specific language in my written testimony submitted for the record.

Rights and Interests of Indigenous Peoples

S. 1733 contains language important to the interests of Indian peoples and can have significance for the benefit of indigenous peoples the world over. I suggest that S. 1733 should include language consistent with internationally recognized human rights, particularly recognizing the right of indigenous peoples to exercise free, prior and informed consent in all matters related to Climate Change. This is a necessary aspect of self-government and it is essential for the full participation of indigenous peoples in the formulation of local, state, regional, federal and international laws, regulations and standards.

I wish to call the Committee's attention to Division A Title 3, which contains several provisions relating to international climate change programs, support for developing countries and involvement of indigenous peoples working to address the affects of climate change. The central concern we have is that developing countries receiving support from the United States must respect the right of indigenous peoples to free, prior and informed consent consistent with international laws and agreements. Furthermore, we believe that this well-recognized standard must become a part of Title 3 in clear terms to ensure that U.S. support does not violate the human rights of indigenous peoples.

It is a well established international human rights standard that states shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources particularly in connection with the development, utilization or exploitation of mineral, water or other resources.

Because of the extreme vulnerability of indigenous peoples in the developing world, just as we experience the same vulnerabilities in North America to rights violations that could otherwise result from climate change mitigation and adaptation activities, the Quinault Nation believes that agreements with developing countries and other entities seeking offset credits or project funding must require:

a) respect for the nationally and internationally recognized rights of indigenous peoples including the right of self-determination

b) provision for prompt and fair demarcation of the boundaries of, and recognition of the collective rights of indigenous peoples to, their lands, territories, and natural resources

c) engagement of indigenous peoples, through their respective institutions, in effective consultation and good faith cooperation, and provides for their full and informed participation in the design, planning, implementation, monitoring and evaluation of any project or activity in all areas that may be affected by the project or activity

d) transparent processes with third party oversight, in order to ensure that indigenous peoples receive the full value to which they are entitled under any project or activity

These provisions must be a condition of any offset credits granted and any project funding aimed at reducing deforestation. In addition, we strongly urge that the United Nations Declaration language regarding *"free, prior and informed consent"* become a part of the legislation's consideration of Reducing Emissions from Deforestation and Forest Degradation (REDD) and indigenous peoples.

The Quinault Nation supports the international standard that indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources and urge that S. 1733 embrace standards to ensure the dignity of indigenous peoples. The Quinault Nation believes that these standards apply to indigenous peoples under Division A, Title 3 and these standards should be no less applicable to indigenous peoples in the United States throughout the bill.

Indeed I urge the Committee to consider an amendment to S. 1733; U.S. Indigenous Peoples: American Indians, Alaskan Natives and Hawaiian Natives as you consider markup. On behalf of the Quinault Nation, I offer the following language for your consideration:

SUBTITLE: U.S. Indigenous Peoples

There is no distinction between "American Indians, Alaskan Natives and Hawaiian Natives" and "indigenous peoples" elsewhere within the context of this law, international treaties and agreements.

SEC 001. Findings.

(a) Climate-driven changes to weather, water, food, natural resources, and landscapes can profoundly affect the lifeways, social identity, and cultural survival of tribal and native communities.

(b) Renewable energy potential on tribal lands is extensive. According to the Department of Energy (DOE), wind energy capacity on tribal lands is more than 20 percent of the United State-installed electric power generated in 2004, and the solar energy potential on tribal lands is four and one-half times the current annual U.S. electric generation. Developing this potential has tremendous and multiple United States and tribal benefits: economic development, energy independence, green jobs, poverty reduction, greenhouse gas reductions, and access to energy resources. Tribes and native communities can and must be meaningful participants in the United States clean energy revolution.

(c) Climate-related policies and programs are being developed at international, national, regional, and state levels without the participation or informed consent of indigenous peoples. The imposition of such externally-formulated climate change policies and programs may infringe upon tribal territorial sovereignty, undermine biological and cultural diversity and fail to respect tribal rights to equitably benefit from the amenities and values provided by their lands and resources.

(d) American Indians, Alaskan Natives and Hawaiian Natives (tribal governing bodies) are distinct political entities that possess inherent sovereign authority, including primary jurisdiction over their peoples, territories and resources. Tribal governing bodies have the right for their people to enjoy the highest attainable self-defined standards of physical and mental health and determine the risks to the tribal population's physical and mental health.

(f) Indigenous peoples have the right to benefit directly and equitably from revenues generated by international, federal, regional, state or local efforts to control greenhouse gases emissions based on target reductions connected to causes and remedies for the affects of climate change. Tribal peoples have been historically left out of federal efforts to support renewable energy and energy efficiency. States have received at least $7.2 billion through the Department of Energy's State Energy Program (SEP) since 1975, including $3.1 billion under the American Recovery and Reinvestment Act of 2009 (ARRA). In comparison, DOE's Tribal Energy Program (TEP) has received $16.5 million since 2002, including zero dollars ($0) under the ARRA, or the equivalent of 0.023% of SEP funding. Further, for decades federal efforts to assist states and local governments regarding weatherization, building codes and other energy efficiency measures have generally overlooked Indian tribes. The "Indian Tribal Energy Development and Self-Determination Act of 2005" in Title V of the Energy Policy Act of 2005 was designed to create the federal and tribal infrastructure, funding and services to begin to address these disparities. To date, this Act has not been meaningfully implemented or funded.

(g) American Indians, Alaskan Natives and Hawaiian Natives are disproportionately affected by climate change due to a dependence on natural resources for economic and cultural purposes. They are located in areas prone to extreme weather events (as recognized by the United Nations Intergovernmental Panel on Climate Change) as well as the relative vulnerability of tribal infrastructure and services.

(h) American Indians, Alaskan Natives and Hawaiian Natives have been excluded from or insufficiently included in a diverse array of federal programs related to climate change mitigation and adaptation, such as renewable energy development, energy efficiency, adaptation strategies, and natural resource management.

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SEC 002. Governing Authority over Territories and Lands

(a) The Congress and the Administration shall not impose restriction or regulations on American Indian, Alaskan Native or Hawaiian Native peoples and territories on matters pertaining to climate change or presume that tribal lands and resources will be managed to provide broad societal benefits or objectives without the free, informed, and prior consent of tribal governing bodies. All measures shall be undertaken to preserve and enhance biological and cultural diversity in tribal territories and adjacent territories. Tribal territories and resources shall not be used to compensate for costs of environmental degradation caused by non-tribal societies around them.

(b) Each tribal governing body has the right to enact such laws and regulations as appropriate and adopt mitigation and adaptation plans within in its jurisdictional authority as it deems necessary to protect and advance the social, economic, political and cultural welfare of their communities in matters pertaining to climate change. Tribal governing bodies may adopt laws, regulations and plans pertaining to renewable energy standards and portfolios (Subtitle A), the emission, capture, and sequestration of green house gases (Subtitle B), smart grid advancement (Subtitle E), and energy transmission plans and rates (Subtitle F). Each tribal governing body has the prerogative to determine and apply best available science, including native sciences and conventional sciences, according to their cultural requirements consistent with the right to determine and identify priorities and strategies for the development or use of their lands or territories and other resources.

(c) Tribal laws, regulations, and plans pertaining to climate change shall be recognized as authoritative and determinative as to the risks, values and benefits associated with measures to adapt to, or mitigate for, climate change effects within the territorial jurisdiction of tribal governing bodies.

SEC 003. Participation by Tribal Governing Bodies in Climate Adaptation and Mitigation Programs

(a) Renewable energy and energy efficiency.
(1) A Tribal Energy and Environmental Development Fund is hereby established.
(2) Funding up to the amount of [funding level to be determined] is hereby authorized for operation of the Tribal Energy and Environmental Development Fund, including [funding level to be determined] for the Department of Energy's Tribal Energy Program.

(b) Mitigation and Adaptation.
(1) A [to be determined%] set aside for federal programs for mitigation and adaptation measures affecting tribal communities.
(2) The set-aside shall be distributed across applicable federal programs to ensure comprehensive, consistent, and sustainable funding for tribal natural resource adaptation activities.

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SEC 004: Intergovernmental Cooperation in Policy Formation

(a) The Administration is directed to provide for official representation by American Indians, Alaskan Natives and Hawaiian Natives on delegations of the United States or as delegations in their own right with recognized governing status, according to each delegation's choosing, in international forums engaged in the formulation, authorization and implementation of treaties, policies, rules, and programs relating to climate change. Where appropriate, the Administration shall provide funding for travel and expenses for U.S. indigenous delegations to international sessions.

(b) The Administration is directed to support representation by other indigenous peoples of other countries in international forums engaged in the formulation, authorization and implementation of treaties, policies and programs relating to climate change

(c) Regional and sub-regional bodies involving climate change initiatives undertaken by state governments which encompass tribal territories and resources shall include representation on a proportional and weighted basis by American Indians, Alaskan Natives and Hawaiian Natives, as appropriate.

ATTACHMENT A

THE IMPORTANCE OF NATURAL RESOURCES TO TRIBES

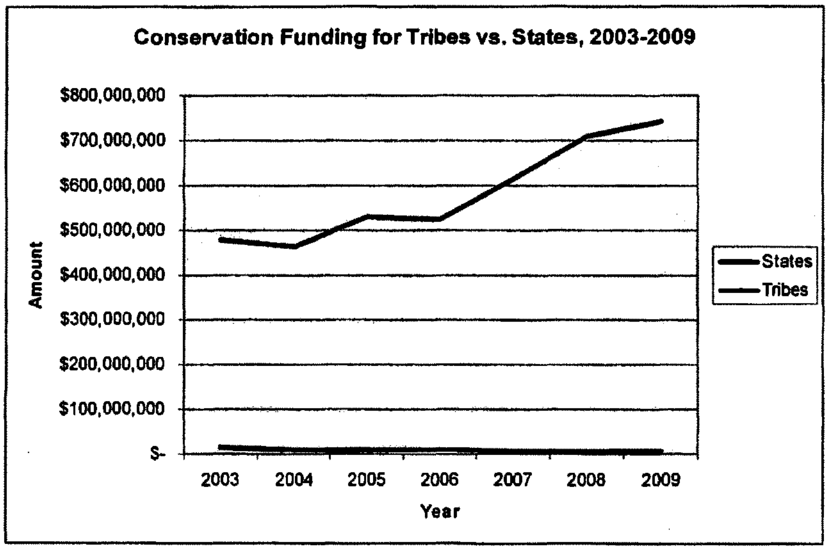
There are 564 federally-recognized American Indian tribes and over 300 reservations in the United States. Land represents one of tribes' greatest assets. Tribes own and manage 95 million acres, which is 11 million acres more than the National Park Service. Tribal lands contain more than 997,000 acres of lakes and impoundments, over 13,000 miles of streams and rivers, and over 18 million acres of forested lands. Tribes operate approximately 114 fish hatcheries, with many producing threatened or endangered fish species. Tribal lands provide vital habitat for more than 525 federally listed plants and animals, many of which are both ecologically and culturally significant to tribes.

Unfortunately, tribes are not eligible for funding under federal wildlife and fishery restoration programs such as the Federal Aid in Wildlife Restoration Act (Pittman-Robertson) or the Federal Aid in Sport Fish Restoration Act (Dingell-Johnson) that fund activities through an excise tax on hunting and fishing equipment – even though they pay this tax like all other citizens. Tribes are also ineligible for Section 6 funding under the 1973 Endangered Species Act (ESA), as amended. Although tribal members pay taxes that support this funding as well, they remain excluded from receiving the benefits and only states are allowed to access these funds.

The BIA programs also fund some natural resource management programs for tribes, but consistent federal budget cuts to BIA for more than a decade have diminished resource management capacity by an increasingly significant amount. Nearly a decade ago, the BIA reported that tribes had over $356 million of unmet annual needs for natural resource management on their lands. Since that admission, in each successive year, all funding mechanisms have remained flat or declined.

In 2002, Congress authorized the FWS to provide funding to tribes under the Tribal Wildlife Grant Program and Tribal Landowner Incentive Programs (TLIP). Tribal proposals for support frequently total more than $30 million annually. Yet these programs combined have only provided an average of $7 million dollars annually to tribes. With 564 federally recognized tribes, competition is severe among tribes. Individual tribes rarely receive sufficient funds to fully support important conservation efforts.

In fiscal year 2007, only 35% of tribal proposals received funding under the TWGP (38 proposals funded out of 110 submitted). As another example, in FY 2003, in the FWS Northeast Region, 9 tribes submitted TWGP proposal requesting $1.4 million, but only 4 (or 44%) were funded for $481,554 (or 34% of the requested amount). In FY 2009, FWS funded 40% of the proposals submitted to the TWGP (41 proposals funded out of 101 submitted). FWS awarded $7 million to tries with a meager average award of $170,000.



State funding includes the U.S. Fish & Wildlife Service (FWS) Wildlife and Sport Fish Restoration Program and tribal funding includes FWS Tribal Wildlife Grants Program and Tribal Landowner Incentive Program.

In FY 2009, states received $740,924,388 from the Federal Aid in Wildlife Restoration Act and the Federal Aid in Sport Fish Restoration Act. Thus, the $7 million tribes received from the TWGP was **less than 1%** of the amount states received. From 2003-2009, states have received 67 times more funding than tribes for fish & wildlife conservation, or $4.06 billion for states and only $60.2 million for tribes.

Tribal lands contain some of the most pristine and undisturbed land and cultural resources in the United States, and thus provide wildlife with some of the best habitat in the nation. Despite the historic underfunding of tribes for wildlife and natural resource conservation, tribes are leaders in managing and protecting their resources. With the current and projected impacts of climate change, tribes will face significant new challenges to sustaining their natural resource management activities as well as planning and implementing climate change adaptation measures. S. 1733 provides an opportunity for the federal government to partially rectify the historic inequity of natural resource funding to American Indian tribes and Alaska Natives. As sovereign nations and managers of 95 million acres of land, it is vital that S. 1733 provide Indian tribes the financial resources and assistance for natural resource adaptation on tribal lands.

ATTACHMENT B

TRIBAL PRIORITIES FOR SENATE CLIMATE LEGISLATION BASED UPON THE AMERICAN CLEAN ENERGY AND SECURITY ACT (ACESA)

Title I – Clean Energy

Title I spurs clean energy generation, energy efficiencies and greenhouse gas reductions through programs and initiatives including among other things: a Combined Efficiency and Renewable Electricity Standard that mandates gradually increasing percentages of energy generation from renewable energy or energy savings,(to be 20% in 2020); a national program to bolster the implementation of Carbon Capture and Sequestration technologies; Clean Transportation such as promotion of clean vehicles, electric vehicles and related infrastructure; support for state renewable energy and energy efficiency activities, and development of smart grid, and transmission planning.

Indian Tribes can and should be meaningful contributors to the nation's transition to clean energy and energy independence. Tribal lands compromise over 4% of the nation's land base and contain 10% of the nation's energy resources. According to the Department of Energy, Tribal wind potential can provide 20 percent of the installed electric power that was generated in the United States in 2004. Tribal solar energy potential can provide 4.5 times the installed electric power that was generated in the United States in 2004. Renewable energy is one of the most significant economic development opportunities available to Tribes during these difficult economic times, particularly Tribes in remote areas which have to date never experienced economic opportunity.

However, the Tribes' ability to participate is challenged by a variety of factors:

- The federal government has yet to provide Tribes support for renewable energy activities that is even remotely comparable to that provided to states over a period of a number of years, constraining Tribal capacity to engage in these activities. DOE has provided states $7.2 billion in funding under their State Energy Program, since 1975, including $3.1 billion under the Recovery Act. In contrast, DOE's Tribal Energy Program has received $22.5 million since 2002 and $0 under the Recovery Act;

- Indian Tribes are not sufficiently involved in national and regional planning efforts regarding access and improvements to the electricity grid;

- Indian Tribes do not have adequate access to financial incentives for renewable energy deployment, such as production and investment tax credits, loan guarantees, and bonds;

- Leasing, siting, and permitting issues in Indian Country hamper the deployment of renewable energy projects; and,

- Indian Tribes dependent upon non-renewable energy sources for revenue to serve their communities/peoples are particularly vulnerable in this transition.

While the ACESA provides Indian Tribes some opportunities to participate in the Clean Energy Title, and are provided a modest amount of funding, improvements are needed, including:

- Increasing the current Tribal set-aside of 0.5% of the allowances provided to states and Tribes for renewable energy and energy efficiency activities, to 5%. (Sec. 132). Furthermore, that set-aside should allow Tribes to build capacity, receive the allowances directly or through the auctioned revenue, and have the opportunity to receive funding where applicable, on a non-competitive basis. (Sec. 133);

- Ensuring that national and regional transmission planning includes Indian Tribes;

- Providing Tribes equitable access to financial incentives for renewable energy production, such as the transfer of production and investment tax credits; an extension of the accelerated depreciation allowance; streamlined processes for leasing, rights of way, and environmental reviews on Indian lands; and,

- Providing specific assistance and incentives to Indian Tribes dependent upon non-renewable energy sources for revenue needed to serve their people.

Title II – Energy Efficiency

Energy consumption associated with buildings accounts for nearly half of the greenhouse gas emissions in the United States. Improving the energy efficiency of buildings is one of the most inexpensive and accessible ways of reducing greenhouse gas emissions. Among other things, this title: establishes new energy efficiency standards for buildings as well as lighting products, commercial furnaces, and other appliances; harmonizes federal fuel economy standards and enact programs to reduce transportation-related energy consumption; increase the efficiency of water use; and promote energy savings by the federal government and other public institutions.

While Tribes are included in some sections, they are excluded from several critical ones. For example, Sec. 201 establishes a national building code and energy efficiency targets for residential and commercial buildings that would achieve at least 75 percent reductions from those baselines by 2030. Tribal governments have the authority to establish and enforce Tribal building codes, and many do, but are not provided the levels of technical and financial assistance provided to states and local governments to adopt these codes and meet targets. Tribes have historically been excluded from federal financial support for code development and implementation, and tribes should be provided 5% of these allowances to engage in these activities as well. In addition, Indian tribes are not included among other things, in: the Retrofit for Energy and Environmental Performance (REEP) program (Sec. 202): rebates for manufactured homes (Sec. 203); a grant program to support enforcement of community building codes (Sec. 207). Top priorities include:

- Tribal inclusion in energy efficiency programs, including Sections 201, 202, 203, 207;

- 5% of the allocations currently provide to states to adopt and comply with the national building code; and,

- Tailoring to the fullest extent possible, such programs into related existing programs in coordination with the relevant federal agencies, such as Department of Housing and Urban Development (HUD), BIA, and the Indian Health Service (IHS).

Title III – Reducing Global Warming Pollution

This title would mandate the reduction of national GHG emissions by adding a new Title VII to the Clean Air Act. This new title would call for GHG emissions reductions below 2005 levels by 17 percent in 2020 and by 83 percent in 2050. Such emissions reductions would be accomplished through a national cap-and-trade program, although 2 billion tons annually in domestic and international emissions offsets could serve as substitutes for some of these reductions. In addition, developing countries could receive allowances for reducing GHG emissions from deforestation. With respect to international efforts, the title's current provisions are much too weak to adequately protect the rights of indigenous peoples, and also fail to acknowledge the status of such peoples as sovereign entities.

Like other titles under the ACESA, Title III fails to adequately address the needs and concerns of Indian tribes. As such, the top priorities for Indian tribes in relation to Title III should:

- Provide Indian tribal governments heavily dependent on revenue from non-renewable energy production and/or the royalties from such activities, with allowances to ease the impacts upon their ability to provide services to their peoples;

- Provide Indian tribes with a five percent set-aside of the allowances made available to states to help offset any increased costs to home heating oil, propane, and kerosene;

- Include Indian tribes in addition to states and local governments as the list of eligible governments to receive allowances to support the deployment of renewable energy infrastructure; and,

- Make clear that all international activities to reduce GHG emissions must be conditioned on a recognition of, and protection of, the national and international rights of indigenous peoples.

Title IV – Transitioning to a Clean Energy Economy

Title IV focuses on three major categories: 1) Reducing industrial emissions; 2) Green jobs and worker transition; and 3) Domestic, Natural Resource, and International Adaptation to Climate Change. While Title IV provides a number of provisions to assist tribes with mitigating and adapting to climate change, Title IV does not adequately address the needs of tribes and their role, and that of other indigenous peoples, as sovereign nations. Title IV also contains numerous provisions calling for the collecting of, and the making of decisions based on, the "best available science," but fails to acknowledge and include the valuable contributions tribal traditional knowledge can make both to assessing climate change and addressing and mitigating its impacts.

The top priorities for Indian tribes in relation to Title IV include:

Regarding Domestic Adaptation

- 6% of the allocations to tribes for domestic adaptation activities, which includes 1% for Alaska Native Villages to address the flooding and erosion that threatens 86% of the villages
- Establishing a federal plan to address the dire circumstances of Alaska Native Villages, as 31 villages currently qualify for permanent relocation
- An 8 percent set-aside for Indian tribes to carry out natural resources adaptation activities, with ½ available through the BIA Trust Natural Resources Program, ¼ available through the FWS Tribal Wildlife Grants Program, and ¼ available through the USDA Natural Resources Conservation Service Program (NRCSP)

Regarding Natural Resources Adaptation

- The 27.6 percent allocation to the Interior Department for natural resource adaptation activities should be apportioned and distributed on an equitable basis based upon land ownership and management, including 16.02 percent of the allocation to Indian tribes in accordance with their responsibility for 95 million acres
- Flexibility and equity must be ensured in the apportionment and distribution of the Land and Water Conservation Fund made available on a competitive basis to Indian tribes and States by conducting consultation among the Interior/Agriculture Departments, Indian tribes, and States

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- No less than 5 percent of the Climate Change Health Protection and Promotion Fund should be made available to Indian tribes to prepare for and respond to the public health impacts of climate change on Indian tribes
- Provisions must be made for taking tribal traditional knowledge into account, consistent with tribal concerns over confidentiality and protection of their rights to such knowledge
- Indian tribes' treaty-reserved rights to First Foods must be protected

Regarding International Provisions

- Communication and coordination among Federal departments and agencies, States, Indian tribes, and other nations and their indigenous peoples regarding common interests in making cross-boundary natural resources more resilient to climate change, and in ensuring the continuing vitality of international treaties and of cross-boundary indigenous treaty rights
- As sovereigns, indigenous peoples should be specifically included as qualifying entities for assistance in Subtitle D's provision for exporting clean technology to developing countries. Indigenous peoples should also be able to receive allowances for adaptation available under the International Climate Change Adaptation Program, and, when allowances go to other entities, if indigenous peoples might be affected, their rights must be protected more fully than provided by the present language

On behalf of the Quinault Indian Nation and the many other Sovereign Nations that support climate change legislation, I appreciate this opportunity to provide this testimony on S. 1733.

Ceoquio [Thank you].

Questions from Senator James M. Inhofe

1. Are you concerned at all about balancing the needs of species adaptation and water with the needs of water users, such as food producers, agriculture and towns who depend on water for their existence?

Response: The Quinault Nation employs a holistic approach to natural resource management that is based on consideration of interactions between species and the environments in which they live. As stewards of the land, we make our management decisions in light of their potential impacts on water, air, soils, and all things that walk, swim, fly, crawl or grow roots in both the short and long-term. The social, spiritual, economic, and cultural foundation that underlies the values of our community differs markedly from species-centric approaches that too often seem to dominate western natural resource management. It makes little sense to seek to lock resources or the environment in a static state or to attempt to recreate conditions that we will not likely ever see again. Our focus is placed not on the past, but rather on the future. We recognize that change is an intrinsic and inevitable part of life. It is our responsibility to try our best to ensure that all things have a pathway that will enable them to adapt. To be sure, water provides many benefits for agriculture, transportation, recreation, and development. But we also recognize that we cannot afford to ignore the needs of plants and animals that also depend on this precious

resource. Humans too must adapt and try to find ways to change their behavior so that others that share the Earth can survive. Thus, in a sense, we practice a "balanced" approach to natural resource management that integrates considerations for species, the land, its resources, and the needs of present and future generations.

2. Are you concerned about balancing the needs of species adaptation with renewable energy's high water needs?

Response: Water is critical to many forms of energy production, whether based on nuclear, hydro, renewable or fossil fuels. As indicated by our response to the previous question, the Quinault Nation's approach to natural resource management considers interactions between flora, fauna, water, air, and soils. When decisions involve the use of scarce resources, efficiency and constraints are prime considerations. If energy production is the prime objective, our focus will turn to how to best meet other needs for water by minimizing withdrawls and pollution, or altering flow patterns to support valuable ecosystem functions. Decisions regarding resource use are not usually "either or", but rather an exercise in accommodation or "balance."

3. Environmentalists in West Virginia recently filed a law suit under the Endangered Species Act, claiming that proposed wind turbines could threaten the Indiana bat. In California's Mojave Desert, *development of solar and wind facilities has been delayed due to concern over the region's tortoise population. Lawsuits and similar scenarios have pitted ESA duties against the importance of renewable energy. As BIA and DOI works to build transmission lines and increase these renewable sources of power on the vast renewable potential that tribal lands hold, how will your tribe and BIA balance the needs to reduce global warming with endangered species protection?*

Response: The species-centric approach embraced by the ESA is incompatible with the Quinault's holistic, ecosystem-based approach toward natural resource management. At Quinault, we take a broader view of management decisions. Instead of limiting options to individual species and the confines of property ownership boundaries, we examine how species can best be protected across the landscape. This approach may involve ways to provide adequate compensation for individual property owners to encourage continued production of ecosystem services desired by society as a whole. When considering opportunities for development of renewable or other energy, the Quinault government must also evaluate alternatives in light of driving forces that affect the values, resources and environment of concern to the Quinault Community. Many of the factors that are contributing to global warming (or influencing air and water quality, or affecting populations of fish and wildlife for that matter), are well beyond the direct control of the Quinault Nation. However, the Quinault Nation can contribute to the task that confronts all humanity by participating in the formulation of agreements, laws, policies, and regulations that affect the emission and sequestration of green house gases at local, regional, national and international levels, and by encouraging the development of alternative energy and energy efficiency. At Quinault, we are undertaking efforts to complete a risk assessment on the values and resources that are likely to be affected by climate change and energy development, exploring opportunities to reduce operational costs by using alternative sources of energy (e.g., heat from woody biomass derived from our forests instead of relying on electricity, oil, or gas), devising approaches that can provide pathways for adaptation for ecological functions, developing programs to minimize our energy footprint, and providing support for weatherization to improve energy efficiency.

4. In your testimony you mentioned the need for tribes to have regulatory deference because as you said, the tribes know and understand better their needs local needs. Having stated that, how could tribes, or even any local government, support a bill that centralizes so much power in the federal government and bureaucracies?

Response: The Quinault Nation is concerned about the imposition of laws, rules, regulations, or policies devised by others. At the same time, we recognize and understand that intergovernmental coordination could reduce the potential for conflict and enhance the effectiveness and efficiency of climate measures. We can support legislation that provides for centralization of power so long as that legislation provides for substantive participation in the development of climate policies and programs, and equitable sharing of costs and benefits. We trust the United States, whether exercising either local or centralized power, will always be mindful of its unique political relationship with Indian tribes and duty to respect the inherent regulatory powers we possess over our lands, resources, and citizens within our jurisdiction. In short, the Quinault Nation expects the legislation to respect our sovereign right to choose for ourselves, akin to the fundamental principle reflected in the U.N. Declaration on the Rights of Indigenous Peoples of free, prior, and informed consent.

Senator BOXER. Thank you very much.

I just want to make sure that you are aware that Senator Udall of New Mexico has really been our point person. So, the thank yous that you gave in my direction I am going to say, without Senator Udall, I do not think we would have done as good a job as we did. So, I just wanted to make that public because he worked so hard, he and his staff.

And now last, but not least, our minority witness. I want to just say that poor Senator Inhofe came in, and he said what happened to my other witness, because he had two. Well, his other witness got H1N1 and there was not enough time.

But here is the really interesting thing. Tomorrow, his—another witness got H1N1. But there was time to replace that witness with another witness. But we wish both of those witnesses well.

Now, Mr. Sims, I am going to welcome you back to the Senate where, as I understand it, you worked for 12 years including as Chief of Staff to former Senator Robert Kasten, Jr., and then you worked in the White House as President George W. Bush Director of Communications for the Energy Group, which was led by Vice President Cheney, and now you serve as Chief Executive Officer of the Western Business Roundtable.

So, we are very pleased to welcome you back to your old homestead.

Mr. SIMS. Thank you.

Senator INHOFE. I might also add that since we only have one minority witnesses, you can have 10 minutes instead of 5 minutes.

Senator BOXER. Well——

[Laughter.]

Mr. SIMS. I am not sure I would ask for that.

Senator BOXER. Well, with unanimous consent, we will give you 7. How is that?

STATEMENT OF JAMES T. SIMS, PRESIDENT AND CHIEF EXECUTIVE OFFICER, WESTERN BUSINESS ROUNDTABLE

Mr. SIMS. I will be efficient regardless since we are a pro-efficiency group.

Madam Chair, thank you very much. Mr. Ranking Member and members of the committee, it is good to be back here. I feel like the Senate is really my home in a lot of ways.

The members of the Western Business Roundtable, Senator Boxer, we are a very wide ranging, broad based group of members, and I think it is fair to say that of our 50 or so members, we probably have 50 different views on what to do about climate change.

We do have a number of things that we do agree upon, though, and I have entered those into my statement as long as that can be placed in the record. I would appreciate that.

Senator BOXER. Absolutely.

Mr. SIMS. I would also mention that I am the co-founder and the former head of what is not known as the Geothermal Energy Association. I am a very strong proponent of renewable energy and have a lot of experience in that area. My job these days running a large, broad based organization is to promote more of everything.

Regrettably, our organization is not able to lend our support to your bill as it currently stands today. What I wanted to do, and I hope I present this in the right way, is to put forth some additional ideas and suggestions, constructive things that can be done in addition to a bill like this or in lieu of a bill like this, whatever the Congress is trying to do.

Our members, and I am very proud of this, our members are companies that are out there right now trying to develop the exact technologies, greenhouse gas mitigation, CCS technologies that will get us to the point where we will be able to grow our economy and mitigate greenhouse gas emissions.

So, we would like to make a couple of concrete suggestions for the Congress and the committee, of course, to consider.

We suggest the launching of four major initiatives, public-private partnerships, along the lines and with the same intensity as this country entered into when we put a man on the Moon in less than a decade. A number of members have talked about some of these very initiatives. For example, we would like to see a public-private partnership put together that would specifically build and deploy at least six 500-megawatt pilot projects near zero emission coal-fired power plans that can demonstrate a wide variety of CCS technologies.

Now, a lot of people are talking about these technologies. Frankly, a lot of them are on the drawing board. We believe we need to get out there in the field, and this is going to require some assistance from the Government, to start building these kinds of technologies.

We would also like to see a major initiative to build out our infrastructure to support compressed natural gas and electric vehicle fleets. That is something that I think a lot of support exists on both sides of the aisle. We would also like to kick start the construction of at least three coal-to-clean liquids and/or coal-to-gas facilities to help us convert the energy locked up in coal in cleaner and cleaner ways.

Finally, we would like to see a dramatic acceleration, I think all would agree with this, a dramatic acceleration of our build-out of the high voltage electric transmission system. I would add that we feel very strongly, however, that as that process goes forward, we need to make sure that we do not restrict access to the grid. We should build lots of wind, solar, geothermal, clean coal, nuclear, et cetera, and all should have access to that grid.

We also would recommend, and I think, Madam Chair, there is no disagreement on this, a much more aggressive push on energy efficiency. And I would also add process efficiency. Energy efficiency looking at building envelopes and standards, those are obviously going to get stronger, and they should. But also there are tremendous efficiencies that can be reaped through industrial processes, whether it is power generation, manufacturing, et cetera. Obviously, the more efficient we are in those processes, the more production we can have with a comparable decrease in emissions.

We also believe, and I think there are a number of members that also agree with this, that we need to find a way, if we are going to make CO_2 sequestration really work, we have got to find a way to deal with the legal liability issue. We have Price-Anderson for the nuclear industry. I think we are going to have to look at some kind of a structure so that, whether it is a Governor or a county or the U.S. Government, when we start seriously sequestering CO_2 underground, we have to understand and know that we are not going to have, quite frankly, a flurry of lawsuits, because that is going to prevent those projects from going forward.

We also believe that we need a massive build-out. The massive build-out of clean energy technologies that we are all seeking, renewables in particular, are also going to require a major increase in this country's ability to do mining and mineral development.

Now, most folks do not put these 2 and 2 together, but if you think about it, a 3-megawatt wind turbine, those are the big ones that you see now going all over the country, one of those wind turbines requires 335 tons of steel, that is one turbine, 4.7 tons of copper, 1,200 tons of concrete, aggregate and cement, 3 tons of aluminum, and 1 ton of something we call rare earth elements.

And I think many of you are starting to hear more and more about the fact that rare earth elements, which are used in wind turbines as part of the permanent magnets, they help us create the electricity. Right now, our country, like it or not, is dependent on one nation for 99 percent of all the rare earth elements that we import. The nation is China. And the reason that is important is that the Chinese, as they are building out their wind power manufacturing and deployment capabilities, they are talking now about restricting their exports of those rare earth elements.

The point being that if want to build a lot more renewables, we are also going to need to have to do a lot more environmentally sound and sensitive mining and minerals development.

Madam Chair, I want to make one note on climate adaptation. There are a lot of things going on in climate adaptation. I think they are all good. Frankly, I am one who believes, and I do not think anyone would dispute this, the climate is always changing. Humans are having a role in that.

But the fact is we need to be careful about adapting to whatever climate we have in our future. I would note, this is a little controversial, I think there is a truth in this issue that frankly is best summed up by Patrick Moore, who is one of the founders of Greenpeace, who makes the point that ice and frost are the enemies of life.

Now, that is not to say that we should not be concerned about global warming. It is to say that as the globe warms, which everyone says it is going to, that some of the catastrophic predictions of species extinctions probably, I believe, are not true. That is not to say that we should not be working to try to prepare for ourselves for any climate adaptation that comes down our path.

Madam Chairman, thank you very much.

[The prepared statement of Mr. Sims follows:]

Testimony of James T. Sims, President & CEO
Western Business Roundtable

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

LEGISLATIVE HEARING ON S. 1733, "CLEAN ENERGY JOBS AND AMERICAN POWER ACT"

Wednesday, October 28, 2009

Chairman Boxer, Ranking Member Inhofe, Members of the Committee, thank you for the opportunity to present testimony today on behalf of the Western Business Roundtable regarding S. 1733, the "Clean Energy, Jobs and American Power Act." We appreciate this opportunity to provide you and the Committee with our views on this legislation.

About The Roundtable

The members of the Western Business Roundtable are engaged in a wide variety of research, development and deployment efforts for greenhouse gas (GHG) control technologies. As a broad-based coalition of companies doing business in the Western United States, our members are engaged in a wide array of enterprises, including: manufacturing; retail energy sales; mining; electric power generation and transmission; energy infrastructure development; oil and gas exploration development, transportation and distribution; and energy services.

We work to defend the interests of the West and support policies that encourage economic growth and opportunity, freedom of enterprise and a common-sense, balanced approach to conservation and environmental stewardship.

Comments on S. 1733

All of our members are desirous of greater legal and regulatory certainty with regard to future GHG regulations. All believe that any climate policies should be federal in nature and should promote economic growth, create new jobs, strengthen the nation's power grid and enhance America's fuel diversity and energy security. All believe that GHG mitigation strategies must unleash America's technological innovation and "can do" spirit to be successful.

Moreover, we believe that the key to unleashing technological innovation is through powerful incentives rather than punitive government policies. Our philosophy is perhaps best summed up by former House Speaker Newt Gingrich, who spoke recently in a C-SPAN interview on how best to approach climate solutions. He said:

> **"The morning you provide incentives for technology development, there will be 50,000 entrepreneurs figuring out how to get the money. The morning you try to do it through regulation, there will be 50,000 entrepreneurs hiring a lawyer to fight you."**

As the Speaker points out, this is a fundamentally different model. It's also a model that has shown time and time again throughout America's history to be the correct model when it comes to technology innovation.

Our Common Sense Climate Principles

When examining individual climate bills, such as S. 1733, the Roundtable views these bills through the lens of a set of 10 "Common Sense Principles" that we believe should guide federal legislators in any climate legislation.

Regrettably, the Roundtable does not believe that S. 1733 meets these common sense principles, and we cannot endorse its passage.

Our Common Sense Principles follow:

1. Congress is best suited to determine how a national greenhouse gas emissions reduction program should work. Therefore, any bill should explicitly preempt the Environmental Protection Agency from regulating greenhouse gases under the Clean Air Act.

2. Federal action should aim to reduce greenhouse gas emissions while also allowing for robust economic growth and job creation across all sectors. Legislation that aims to reduce emissions by forcing a further contraction of our economy -- by artificially constricting energy supply and encouraging higher prices -- will choke any economic recovery and will be soundly rejected by the American people. Therefore, cap-and-trade legislation should include some form of "safety valve" to ensure that the American people are not subjected to wild swings in energy prices or runaway cost increases.

3. Federal action should incorporate, as part of any greenhouse gas emissions reduction program, a fully transparent cost-benefit assessment that yields a net positive outcome and achieves wide consensus. Consumers must be made fully aware of the potential economic impacts of proposed policies, prior to any vote in the Congress.

4. Federal action should encourage the rapid research, development, demonstration and deployment, through public-private partnerships, of a broad spectrum of supply-side and demand-side technologies and practices aimed at managing greenhouse gas emissions.

5. Federal action should allow the electric utility sector to continue to supply consumers with adequate supplies of clean, affordable and reliable energy and to recover all costs necessary to achieve any greenhouse gas emission reduction levels sought by public policies.

6. Federal action should involve all sectors of the economy, all sources and sinks and all types of greenhouse gases.

7. Federal action should recognize that climate change is a global phenomenon that requires comprehensive, long-term and coordinated worldwide responses. Unilateral action by the U.S. -- without comparable commitments to reductions by emitting nations like China and India -- will harm our ability to compete in world markets, export U.S. jobs overseas and will result in no measurable change in future climates.

8. Federal action should recognize that the time frame for implementation of any greenhouse gas emission reduction requirements must be tied to technology availability, reliability and economic feasibility in order to avoid unacceptable impacts on consumers and the electricity grids.

9. Federal action should target revenues generated by a climate change program to the rapid development and deployment of technologies to capture and store greenhouse gases, to appropriate assistance programs that help end-use consumers deal with higher energy costs, and to reasonable climate mitigation initiatives.

10. Federal action should allow greater access to public lands (both onshore and offshore) for the development of domestic energy resources -- such as renewables, oil and gas, oil shale, coal and nuclear power -- so that America can continue to seek greater energy independence.

Getting The Legislation Right

While virtually all scientists agree that the Earth has been warming since the end of the "Little Ice Age," average global temperatures have not increased or have declined for the past 8 or so years. This cooling has proceeded in spite of the fact that manmade GHG emissions have continued to increase. Many climatologists – including those who believe strongly that anthropogenic GHG emissions are the primary driver of global warming – now predict that this global cooling may persist for one to two more decades, if not longer.

This remarkable change in our climate is something that virtually none of the climate models predicted. I think that it also underscores the importance of taking our time and getting climate policies right – particularly with regard to advancing and commercializing the technologies that we, and the rest of the world, will need to abate GHG emissions.

The American people increasingly appear to agree with a more deliberative, thoughtful approach to crafting legislative solutions to climate change.

For example, a new poll by the Pew Research Center for the People & the Press finds a sharp decline over the past year in the percentage of Americans who see solid evidence that global temperatures are rising. According to the survey, conducted between Sept. 30 and Oct. 4 among 1,500 adults reached on cell phones and landlines, fewer respondents also see global warming as a very serious problem; 35% say that today, down from 44% in April 2008.

The survey also points to a decline in the proportion of Americans who say global temperatures are rising as a result of human activity. Just 36% say that currently, down from 47% last year.

Getting Technology Deployed

Furthermore, we believe that Congress must exercise great caution with any climate legislation in order to insure the necessary time and capital availability to facilitate the commercial viability of a range of advanced energy technologies.

Commercial development of many advanced technologies such as coal and natural gas power generation with CCS, utility scale solar power systems, transmission infrastructure upgrades and expansion, as well as other promising emerging technologies, will take a growing economy and capital for the necessary investments. This is particularly true for carbon capture and storage technologies tied to fossil fuel power generation.

The world hopes to achieve an across the board 50% reduction in GHG emissions by 20S0, it can not be accomplished without CCS.

Constructive Suggestions For Action Now

Because the Roundtable is not able to support S. 1733, we wish to offer the following constructive and specific recommendations for inclusion in other GHG reduction bills:

- **Coal with CCS Demonstration Projects** – Federal assistance and incentives necessary to construct at least six 500-MW pilot zero-emission coal-fired power plants that can demonstrate a variety of technologies related to CO2 capture and sequestration technologies at altitude in the West.

- **Compressed Natural Gas and Electric Vehicle Fleet Vehicle Demonstration Projects** – Federal assistance and incentives to support at least 25 demonstration projects across the Western U.S. to enhance the ability of vehicle fleets to use compressed natural gas and/or electricity as fuel.

- **Coal-To-Clean-Fuels Demonstration Projects** – Federal assistance and incentives to construct at least three coal-to-liquids or coal-to-gas facilities that can demonstrate a variety of technologies related to CO2 capture and sequestration technologies at altitude in the West.

- **Emissions Reductions Through Process Efficiency Incentives** – Legislative and tax incentives to encourage greater energy efficiency gains through technology deployment by the utility, power production, manufacturing, natural resource development and transportation sectors.

- **Clean Energy Deployment Incentives** – Legislative, tax and regulatory incentives to spur investment in a broad suite of clean energy generation technologies, including renewables, hydropower, clean coal with CCS, oil and gas and nuclear.

- **"Apollo-Program-Level" Funding for CO2 Capture, Transportation and Sequestration Deployment** – Legislative, tax and regulatory incentives to dramatically speed up development and deployment of GHG capture, transportation and sequestration technologies for use by all industries in the West.

- **Limit Legal Risks Related To CO2 Sequestration** –Legislation and regulatory reforms that ensure that CO2 sequestration project proponents can move forward without fear of endless liability lawsuits.

- **Reduced Foreign Oil Dependence Through CO2 –Driven Enhanced Oil Recovery** – Provisions to encourage the rapid build-out of the infrastructure necessary to allow greater use of CO2 sequestration for enhanced oil recovery.

- **Clean Energy Infrastructure Build Out** – Incentives for new investment in transmission lines supporting all Western generation sources, oil and natural gas pipelines, CO2 pipelines and other infrastructure facilities.

- **Cost-Benefit Assessments** – Provisions that require a rigorous, independent cost-benefit assessment to be conducted before any GHG legislation be approved by the Congress.

This last recommendation is a very important one, in our view, given that the ultimate success of any climate program is broad and lasting acceptance by the general public. We agree with elected officials such as Wyoming's Democratic Governor, Dave Freudenthal, who has warned that unless consumers are made fully aware of both the costs and the benefits of climate plans – prior to their implementation – we run the risk that those policies will prove highly unpopular and will run into a lot of difficulty in terms of implementation and enforcement.

I would go Governor Freudenthal one step further: I believe that climate plans that try to effectively "hide the ball" from consumers on the fact that they will bring higher costs and lower standards of living are destined to be repealed because of an avalanche of consumer outrage over those impacts. Of course, the mechanism that consumers will use to force that repeal will be wholesale changes at the ballot box.

From the perspective of our members, such a flip-flopping of major government policy would be a massive setback to the entire climate solutions movement.

Climate Adaptability Issues

There is one bright spot in the climate issue. All across the nation, government and business leaders are thinking much more seriously about how to prepare for a future where temperatures may be different than those we experience today.

One area of concern often cited in the news media is the potential impact that global warming may have on species other than homo sapiens.

On this issue, I think it is important to note the words of Patrick Moore, founder of Greenpeace, when he reminds that: **"Ice and frost are the enemies of life."** What he is saying is that all of the dire and catastrophic predictions of global-warming-caused extinction of hundreds of thousands of species are, to borrow a phrase, a bunch of hot air.

In short, the scientific record shows very clearly that species have adapted to changes in our climate much larger than those predicted by the climate models, and have done so for many hundreds of millions of years.

As noted in a recent book by Drs. Craig and Sherwood Idos, and published by the Science and Public Policy Institute, the IPCC has projected that "globally about 20% to 30% of species (global uncertainty range from 10% to 40%, but varying among regional biota from as low as 1% to as high as 80%) will be at increasingly high risk of extinction" by the year 2100 due to CO2-induced global warming (Fischlin et al., 2007). However, a substantial body of research indicates that the vast majority of the predicted extinctions will likely not occur.

> "This is primarily because in a CO2-accreting atmosphere most plants prefer warmer temperatures, so that while warming gives them the opportunity to move poleward in latitude and upward in altitude at the cold-limiting boundaries of their ranges, it does not mandate that at the heat-limiting boundaries of their ranges they must move in these directions. Consequently, with the greater over-lapping of plant species ranges that these phenomena portend for concomitant increases in atmospheric temperature and CO2 concentration, there should be a tendency for regional plant species richness to actually increase throughout the world; and this same type of range overlapping will likely apply to many of the world's animals that rely upon these range-expanding plants for their food and habitat. Therefore, the end result of the several processes is a future in which there will likely be a great CO2-induced proliferation, as opposed to extinction, of species within numerous geographical areas; and there is much evidence from the peer-reviewed scientific literature to support such an outcome.

Sentencing Species to the "Jail" of the ESA

While S. 1733 does directly address issues related to the functioning o the Endangered Species Act, a number of activist groups are pushing for government policies that make much greater use of the ESA law as a means of "protecting" species from predicted climate change.

The problem is that this law is a broken and outdated law that rarely helps species actually recover to help. This law:

- Discourages innovative environmental conservation;
- Effectively confiscates private property;
- Denies folks their livelihoods;
- Costs our economy many billions of dollars per year with little positive benefit;
- Prevents well-meaning experts at the U.S. Fish & Wildlife Service from doing the real work of helping species flourish; and
- Most important, fails miserably in the central mission that Congress intended to achieve with its passage: recovering species that are in trouble and allowing them to go off the ESA list.

Let me point to just one statistic, taken from U.S. Fish and Wildlife Service data: the ESA has, over its 30-plus-year history, racked up greater than a 99 percent failure rate when it comes to species recovery. In other words, the ESA helps species recover to health less than one percent of the time.

Can any of the Committee Members name any other law with such a breathtakingly consistent record of failure over such a long period of time?

ESA is like a doctor who tells me that my six-year-old daughter has a potentially life-threatening illness, but then prescribes a treatment regime that involves hospitalizing her with no active treatment, no medications, no therapy and no visitors to her bedside. Would it be rational for me to stand by and support this "let Nature take its course and, hopefully, things will work out" approach? Of course not.

On the other hand, the Act does do two things very well:

1. It transfers control of vast swaths of land in the West from private landowners and/or states that control the land to unelected federal bureaucrats and environmental extremist groups.
2. It provides a very, very good living for a relatively small group of trial lawyers and professional environmental extremists who use never-ending lawsuits to warp this well-meaning law to serve their own narrow political agendas.

Will Cap-and-Trade Bills Create Millions of New Jobs?

The public hears virtually every day from a variety of politicians that cap-and-trade plans will create millions of new "green jobs." But have the Members of the Committee actually examined the studies that make these predictions?

One such impartial analysis of a major "green jobs" study was done recently by a Roundtable member: Kimball Rasmussen, President and CEO of Deseret Power in Utah. I highly recommend reading Kimball's relatively short analysis. In it, he finds that:

> "... the promise of millions of green jobs claimed by proponents of the American Clean Energy Act is not supported" by the Jobs and Economic Development Impact model (JEDI), which itself forms the heart of a joint study by US DOE and the National Renewable Energy Laboratory (NREL), known as the 20 x 30 Study.

Further, the Rasmussen analysis finds the following:

- The 20 x 30 Study's forecast of 6.2 million new "green jobs" from the construction of wind turbines "does not reflect the number of long-term, full-time jobs created; instead it's a cumulative count of full-time equivalent workers aggregated for the 24 years in the study period (2007 through 2030).

- "This questionable method of double counting misleads one to think that 6.2 million jobs equates with 6.2 million people that are employed at a time. This is far from the truth. For example, if an individual works for Project 'A' in Minnesota in 2007, and then project 'B' in North Dakota in 2008, and so forth through 2030, the model counts that single worker 24 times."

- "If the indirect and induced impacts are excluded, the gross number of direct jobs is only 121,417, or 2.4 percent of the five million jobs promised. This level of green job creation will not be achieved for another decade; yet we have recently lost more than 400,000 jobs each month based on current economic conditions."

- "When wind jobs are compared head-to-head with coal-fired electric alternatives, the gross job gains in wind are more than offset by net job losses in coal. Every new wind-related job comes at the cost of 1.5 to 2.7 coal-related jobs."

- The study "fails to show the dampening effect on the economy of significantly higher power costs associated with wind power, as well as carbon tax programs."

Disproportionate Impact On Low-Income Populations

Rising energy prices especially hurt low-income families because they must devote a much higher share of their personal income to energy. Since a larger percentage of minority families are among low-income households, they are disproportionately burdened by rising energy prices. Cap-and-trade plans like S. 1733 could exacerbate this economic disparity by raising energy prices, and the costs of goods and services that are energy-sensitive.

Energy cost increases are extremely regressive, and increased energy costs impact the already-strained resources of the lowest-income households. Rising energy costs inflict particular harm on many minority families: lower-income families are forced to allocate larger shares of their budget for energy expenditures and a larger percentage of minority families are among the lower-income brackets. This disparity between minorities and others means that rising energy costs have a disproportionately negative effect on the ability of low income, minority families to acquire necessities -- food, childcare, and healthcare. Unless energy costs are kept affordable, or unless steps are taken to ameliorate the impacts of rising energy costs on vulnerable and minority populations, these costs can have the effect of a discriminatory tax based on income and race.

Share of Income Consumed by Increase in Energy Prices Since 2001

Income Category	Less than $10K	$10K-$30K	$30K-$50K	More than $50K	Totals
Increase in Energy Costs Since 2001	$1,525	$2,353	$3,983	$4,190	$3,403
Increase as % of 2008 After-tax Income	29.5%	13.5%	12.4%	5.4%	6.5%

Summary

While the Western Business Roundtable cannot support S. 1733 and proposals like it, we do believe that a great deal can be done to move America forward on the path to a cleaner energy economy. We are pleased to provide constructive suggestions in this regard, and we look forward to working with the Chair, Ranking Member and all Members of the Committee in this effort.

Responses To Post-Hearing Questions

From Senator Bernard Sanders:

Q: We know in Vermont that energy efficiency has tremendous value, and even though Vermont is a leading state, Vermont projects even greater efficiency savings in future years. Energy efficiency is a proven way to create jobs and save consumers money, while reducing emissions. Would you agree that this Committee should set flexible, cost-effective energy efficiency investment criteria for a portion of the allocation that is provided for free to electric LDC's under this legislation, just as this legislation does for the natural gas allocation?

ANSWER:

Improving the efficiency of an electric or natural gas distribution system is almost always the most economic option for maintaining the reliability of a system while demand grows. Our utility members are especially innovative in finding ways to improve their internal system efficiencies as well as providing their end-use customers with attractive incentives and options to participate in energy efficiency programs. However, history shows that the most successful energy efficiency programs are those that are not dictated to companies or consumers in a top-down fashion by government mandates, but rather are those programs that earn consumer buy-in through attractive incentive programs. While you describe your criteria as "flexible," they are packaged within a framework of heavy-handed government mandates. We think an incentive approach by government in this area works much better.

From Senator James M. Inhofe:

Q: In your Comments on S. 1733, you say that your members are desperate for legal and regulatory certainty with regard to future GHG regulations. Would the Western Business Roundtable like to see the US Congress pass legislation barring the Environmental Protection Agency from regulating GHGs whether or not climate legislation is passed?

> A: Absolutely. In addition to those of our members involved in energy production and natural resource development, I am certain that literally millions of farm and agricultural operators, small businesses, schools, hospitals, hotels and motels, manufacturers and small businesses would also welcome such a bill, given that EPA regulation of GHGs under the Clean Air Act would eventually subject them to costly and economically unsustainable regulation. EPA's unilateral attempt to change the current law and exempt small emitters will fail under legal challenge (which will, ironically come from the environmental community). That will mean that the corner flower shop and millions of other small businesses will eventually have to seek a PSD permit or engage in the NSR process if they ever expand their business and try to create new jobs. And THAT will lead quickly to a wholesale rejection by the public of this entire approach to GHG mitigation.

Q: Specifically how does the Western Business Roundtable see its members being directly impacted by job losses to other nations as well as a loss of competitiveness throughout the world if the US passes climate change legislation without a strong commitment from nations like India and China?

> A: Virtually all of our members believe that imposition of a cap-and-trade regime such as that contained in S. 1733 will result in an almost immediate loss of competitiveness by U.S. companies in global markets. The mechanisms driving this loss of competitiveness are detailed in this highly regarded analysis conducted by Science Applications International Corporation (SAIC) for the American Council for Capital Formation and the National Association of Manufacturers. You and your staff can see a good Executive Summary of that study here: http://www.accf.org/media/dynamic/3/media_381.pdf
>
> We believe that most states will lose under either the Waxman-Markey bill or the Boxer-Kerry bill, and will not have enough allowances to cover their emissions from electricity generation. As noted in **this illustration**, "this shortfall in allowances will lead to higher electricity costs for consumers, the total of which will roughly correlate with the dollar losses noted on the map. Midwestern and Southern states will be the hardest hit. To make up the shortfall, states will have to seek high-cost, non-CO2 emitting electricity sources, reduce electricity production and consumption, purchase allowances, or purchase domestic and international offsets, likely a combination of the three."

Q: Having members in energy sales, electric power generation and transmission, energy infrastructure and development, and energy services, do your members see the technology available to reliably and feasibly implement stringent greenhouse gas emissions requirements?

> A: Virtually no one with any direct experience in CCS technology deployment believes that the technology needed to meet these requirements on the timelines dictated by this bill will be commercially available except at very high cost, which of course will be passed on to consumers. All of our members believe that these technologies can and will be developed - and many of our companies are working on them now. But deployment of breakthrough technologies like these always comes in stages, with various prototypes of power plants and systems built one after the other so we can see what works and what doesn't. Ironically, activist groups on the left are effectively preventing any new high-tech coal-fired power plants from being constructed. This, in turn, stymies efforts to move us along the technology development curve and get to near-zero-emissions facilities sooner.

This is why our group believes that an aggressive partnership between the private sector and the government - conducted with the focus and intensity of the Apollo space program - will deliver these technologies sooner and more efficiently than government dictates, mandates and punitive regulation.

Senator BOXER. Thank you very much.

I am going to think about that, when ice and frost our enemies of life since Greenpeace thinks our bill is too weak, I think you took that point a little out of context.

[Laughter.]

Senator BOXER. But I guess if you are a polar bear, ice is good. If you are an ice skater—but no, we will get there later. But thank you.

I felt that your points were very well done. Hey, you have to start the clock. Have you put a cost to your plan? It is a public-private partnership and it is pretty big, visionary.

Mr. SIMS. It is, Madam.

Senator BOXER. So what do you put as a cost to taxpayers of this?

Mr. SIMS. We have not, but we will do that. We have a number of people on it right now. I will get that back to the committee.

Senator BOXER. Please. Because I am looking at this, and I am thinking, you know, one of the interesting things about the approach we are taking is that the 7,500 largest polluters, as you know, will have to buy the allowances. It is a polluter pay type of a program. Now, my colleague calls it a tax. It is not a tax because if you clean up your act, and you figure out how to get the carbon out of the air, you do not have to do anything. So, it is not a tax. It is polluter pay.

So, the point is, that is different than taxpayer pay. And that is why I ask you for the price that you would put on these things. It may be that they are very worthwhile, some of these ideas. So I am very interested in hearing from you.

Mr. SIMS. Can I make a quick suggestion in that regard?

Senator BOXER. Please do.

Mr. SIMS. Speculating, as well do, on the outcome of this debate and this legislative process, if it is the case, Madam Chair, that the bill passes, a bill like this passes, I think, being practical, as my member companies tend to be, I think a lot of folks we can reasonably project that the regulations that would be written to implement such a bill will be, like it or not, in the courts for a number of years. I think all sides will probably be suing, quite frankly, to change those regulations.

And part of the reason that we are putting forward things that we think can be done in the near term is that these are things that can be done in the near term, possibly while the outcome of this debate continues to go forward.

So, our member companies are out there on the ground now, actually trying to make these things work, and we are looking for whatever assistance we can to push that ball forward.

Senator BOXER. I hear your point. I think it is an interesting point. I would, however, say do not underestimate that there would be lawsuits over some of the things that you put on the list. It is just the way it is. And the question is, how swiftly it moves. It took time, but we finally got the ruling from the Supreme Court that carbon is covered by the Clean Air Act.

So, we need to move forward. And I would suggest to you that the one way we know we have lawsuits is if we do not move forward on that because the Supreme Court has ruled. So, whether

EPA does it or we figure out a more flexible way to do it, it shall be done.

I guess I want to ask our representative of the Native American tribes here, since she is representing one tribe but she did talk about the Alaska Tribes, this idea that ice is the enemy, and frost. When I visited Alaska, well, I actually visited Greenland and Alaska—when I visited Greenland and we met with the tribes there, they are just devastated with the melt. Devastated. I mean, everything that they have done for generations is changing.

So, I wonder if you could comment on that. I mean, I just do not agree with that comment.

Ms. SHARP. Sure. Absolutely. A lot of thoughts went through my mind as I heard the testimony. You know, when you think of Chief Seattle's quote, I do not know how many of you have ever read Chief Seattle's quote, he talks about what we do to the earth we do to ourselves, all things are connected. And it seems that there is a collective value.

And we, as native people, have a deep reverence for the natural world, the natural environment, because we receive air, we can breathe, we receive water, we receive food that nourishes and feeds our bodies. And so, we see an intimate relationship with all aspects of the physical environment, and the degradation of any one physical aspect on the earth has a domino effect.

The glaciers that I mentioned in the Upper Quinault that feed the Anderson Glacier, that is now gone. That water provides essential water flows for salmon, and the salmon are essential to our culture and our value system, and that maintains our continuity as a people.

Senator BOXER. Thank you. I think that is beautifully stated.

Mr. Young, my fellow Californian, could you describe why wastewater facilities are vulnerable to the expected impacts of global warming and how those impacts are addressed in the adaptation provisions of out bill?

Mr. YOUNG. That impacts I think that we are talking about are because of location. Because of the immediate impact of flooding, of rising sea water inundating already perhaps challenged facilities. This causes the opportunity for sanitary sewer overflows, for impacts on public health, for contamination in our streams and rivers, and all of these impacts that are there.

How the adaptation section of this bill can help is with the challenge grants that are offered so that the most serious problems can rise to the top of the list, and the most serious partnerships can be made between the local agencies and the Federal Government to go out and solve those issues in a partnering way, to be able to come up with solutions that can be applied throughout the country.

Senator BOXER. Thank you.

Senator Inhofe.

Senator INHOFE. Thank you, Madam Chairman. Well, first of all, on the consumer polluter pays, let me quote the Director of CBO, Director Elmendorf, he said at any point in which we are putting a price on carbon emissions that would be passed through to the cost to consumers, is it possible to design a system using the revenue it generates to ensure no net increase in the overall burden to consumers. His answer is no.

Mr. Sims, you raise some questions that I think are significant in terms of preemption that we would want to make sure that, the argument has been made that you have to pass legislation to preempt the Clean Air Act. Does this, in any way, preempt that?

Mr. SIMS. I think that, and I will admit, Senator Inhofe and Senator Boxer, that I am still reading the bill. I would have liked to have built it in 25 pages. I am sure we all would have liked to. It is just not possible to do that. So, we are still examining it.

But I know that there is no provision, as far as I know, that would specifically preempt additional action by EPA. Now, obviously EPA is going to have to write the regulations to implement much of this bill. So that is going to happen regardless.

I think our concern was that if the Congress does not act in some fashion, does not provide some legislative and regulatory certainty, we are going to continue to have problems. Our members agree with that. By the same token, we are concerned if Congress does not act, and the EPA goes forward. The EPA does not have the tools under the Clean Air Act to adequately regulate greenhouse gases. Clearly. I do not think their recent change is going to regulate farms and cows with—farms that have 25 cows on it.

Senator INHOFE. And I would also say what provisions of the bill would help us get more natural gas out of the ground?

Mr. SIMS. I think there is an irony, Senator. You make a great point. I am afraid that a good piece of this bill and other bills that we are seeing come out of the Congress are aimed, ostensibly, at increasing America's energy independence while at the same time they have elements that are decreasing our ability to move toward that goal with regard to natural gas and oil development.

We have enough natural gas, we have enough oil, domestically, specifically off our coast, and with oil shale, to move completely to energy independence. But I am afraid we are not going in that direction.

Senator INHOFE. Yes, well, the last thing that I asked you was if it is in the bill or if you have seen it because some of these answers, as you mentioned the carbon capture sequestration, is there anything in the bill that would remove the barriers to that?

Mr. SIMS. There are. And I think a lot of the details will still be worked out. As I said, a lot of the devil that will be in the details from this bill, I think, will come in the writing of the regulations. So, frankly, from our perspective there is a lot of stuff that needs to be filled out, and no one really knows what some of these details are going to be until those regs get written and the inevitable court challenges get adjudicated.

Senator INHOFE. Well, I think you bring out a good point when you talk about getting some of these resources, like natural gas, in previous—and I want to get this into the record, in each one of our hearings the new report that came out just last week from CRS designated or revealed that American's combined recoverable natural gas, oil and coal reserves as the largest on earth. We are No. 1.

Now, the problem is that we are precluded from developing 83 percent of that by regulatory obstacles that are out there. Do you see anything in this bill that would relieve any of those obstacles that are there?

Mr. SIMS. I am afraid to say no, Senator.

Senator INHOFE. One of the concerns I have is, if you get beyond this bill, some of the same people who are promoting this bill are also for some of the other provisions, for example, doing away with hydrologic fracturing. You mentioned getting more of the oil and gas. Obviously, if you remove hydrologic fracturing, you would have a real serious problem doing that. I think you would agree with that.

Mr. SIMS. Senator, I would say there is a tremendous irony in that threat as well. One industry that would probably be hurt the worst by shutting off or slowing down our natural gas production is wind. Wind energy, as most of us I think now understand, is an intermittent resource, and it desperately needs natural gas to help balance out the load. The two work well together, hand in hand.

Senator INHOFE. Yes, well, I think what I am saying is that the one thing that bothers me more about the debate than anything else in when people say, oh, we are concerned about the dependency on foreigners for our oil, gas, our energy, when in fact the reason we are is our regulations over here. And if we wanted to be energy independent, all we need to do is get rid of these barriers that are there. And these are legislated. I am talking about moratoria for offshore drilling and you mentioned the immense oil shale and methane hydrate deposits. Those are huge, and they are not even considered in this conclusion that we are No. 1 in terms of reserves.

Mr. SIMS. Right.

Senator INHOFE. We have far more than China, far more than Saudi Arabia. It is mind boggling to me that, in this debate, we never talk about doing something to reduce those barriers.

I see a lot of shifting around over here. Do you disagree? Do any of you guys really want to keep the barriers there so that we cannot produce our own, develop our own resources?

Dr. Frumhoff.

Mr. FRUMHOFF. I would be happy to respond. Thank you, Senator.

I think the challenge is to make sure we have a level playing field that takes into account the true price and cost of energy use, which this bill would establish through putting a price on carbon. Once you have a price on carbon, along with other corollary policies, then the appropriate mix of energy resources can be better——

Senator INHOFE. Yes, but that was not my question. My question was, should we not develop our own resources?

Mr. FRUMHOFF. I think we have to look at the cost of extraction. Obviously, in the case of offshore drilling the cost of extraction, the environmental and societal costs of extraction are very high. If we have lower cost ways of essentially achieving the same energy benefits through the low hanging fruit of energy efficiency——

Senator INHOFE. Well, how do we find out if we are not able to go after 83 percent of those resources reserves that are out there? How can you determine what the costs are?

Mr. FRUMHOFF. Well, most environmental assessment with which I am familiar suggest that the environmental costs of that extraction would be very high. And that is why I think it has been wise to look for other approaches to achieve our energy independence and to reduce carbon at the same time.

Senator BOXER. Thank you, Senator.

I am just going to put into the record, Mr. Sims, I know you have not read the whole bill, but if you look at section 191, subtitle H, what you will find is a whole natural gas section. And the natural gas industry is working with us, the American Natural Gas Association, because different from the House bill, and different from Lieberman-Warner, we have a natural gas title here, subtitle, and what we allow for is, if you are plugging up a leak from a natural gas pipeline, that is an allowable offset.

That is No. 1, and it huge for them. It is very good for them. And second, there is an authorization to help them build cleaner plants. So, please know that we agree with you that natural gas is very important, it is very abundant apparently, and we are working with them to do even more. But we have come a long way.

And at this point, is it Senator Whitehouse? Or is Senator Udall first?

Senator Udall followed by Senator Whitehouse. OK.

Senator UDALL. Thank you, Madam Chair.

Senator BOXER. Oh, I am so sorry. In between the two of you is Senator Alexander. Forgive me.

Senator UDALL. He has been waiting there, patiently.

Madam Chair, thank you for your very kind comments about my advocacy for tribes. I think you also have been very attentive to tribal needs, and in particular, worked hard, I think, to protect California tribes, and you are a real champion of tribal sovereignty.

With that, let me ask President Sharp. It is my understanding that the Quinault Indian Nation, and other Indian tribes, have been engaged extensively over the past several years to establish intergovernmental cooperation at State and Federal levels. We have had some success in improving the coordination and cooperation with Indian tribes in this legislation so far.

But what would you suggest we do to strengthen provisions to support tribal participation in such forums in this legislation?

Ms. SHARP. I think, probably, the main thing that we would seek is that tribes have a direct and specific policy, what I call policy and regulatory deference. Tribes are in the best position to know and understand the problems that we confront and face at home. We have extensive oral history throughout many generations.

And we would like to be able to blend western science with traditional knowledge. And to be able to do that effectively, tribes should be given regulatory and policy deference as we develop our own standards, our regulatory structures, as well as how that impacts our economy within reservation lands.

Senator UDALL. Now, this legislation that we expect to pass here through the committee in the next couple of weeks is expected to be combined with the Senate Energy Committee, and we also hope to include legislation on tribal energy being developed by the Senate Indian Affairs Committee.

Should this legislation be improved to encourage and facilitate tribal development of clean, renewable energy?

Ms. SHARP. Absolutely.

Senator UDALL. What would you suggest there?

Ms. SHARP. I would suggest that, if Congress and Members of Congress in leadership could take a step back to really understand that tribes, in this particular issue, need to be direct participants. We have advanced these issues locally, regionally, nationally and internationally operating under this assumption. We are facing a global crisis that is of apocalyptic concern.

In those circumstances, it is not right for us, for me as a policymaker of one jurisdiction, to operate in a vacuum. Not only a human vacuum, a mankind vacuum, but to look at the interests that transcend borders. And leadership in this era, in this time, demands and requires that all public policymakers draw on all information, economic information, cultural, historic information, scientific information.

And so, I would strongly encourage that this Congress realize the value that Indian country brings when tribes do collaborate with the Federal Government on restoration efforts that blend traditional knowledge. The benefits are multiplied. And we are at an era where it is such a crisis, we need all information to make calculated decisions moving into the future.

Senator UDALL. Thank you. That is very well put.

Mr. Schweiger, in New Mexico, we are already seeing the early impacts of climate. The Jemez Mountains west of Santa Fe saw the biggest average increase in temperature and decrease in moisture of anywhere else in the State in 2008. Those change likely contributed to a massive Pinion Pine forest die off in the mountains that we have not seen in a long, long time.

Now, natural resource adaptation is an unfamiliar phrase to many folks, even those who may be familiar with traditional conservation efforts. Could you describe a few examples of the types of projects that would be pursued under this legislation, including the investments made in communities and the jobs that would be created and preserved?

Mr. SCHWEIGER. Thanks, Senator. I think the great challenge we have today is that the ecosystems that we have tried to protect in previous actions may, in fact, be disconnected from the resources themselves. And there are some places where we need to create corridors where wildlife—and we also need to take steps to protect stream sides from over warming through planting of buffer strips and reducing the temperatures of stream side corridors.

We also, I believe, have opportunities to take steps to deal with coastal sea level rise and invest in protecting habitats that will someday be submerged while than allow those habitats to be built upon today.

So, there are a number of things that we can do. I also think that, you know, we need to remember that in order to stay even with climate change today, the animals, birds and plants need to be moving at about 30 to 43 feet per day according to the best calculations that we have seen. So, it means that we need to help them move either up slope or move further north to make those adjustments.

It is going to redefine conservation. And frankly, I think there are a lot of really good minds working on what that looks like because it is not going to be the same thing as we had 40 or 50 years ago. We need to rethink how we manage natural resources to protect the living resources and plants to help them adjust to the climate consequences that we are causing.

Senator UDALL. Thank you, and thank you to the entire panel. Thank you, Madam Chair.

Senator BOXER. Thank you, Mr. Schweiger. That was really fascinating to listen to you.

Senator Alexander.

Senator ALEXANDER. Thanks, Madam Chairman. And thanks to the witnesses for being here.

A couple of things for the record. First, the Chairman and I have gone back and forth a little bit about the costs of wind power versus nuclear plants. I accept the National Academy's conclusions that climate change is real and that humans have probably caused most of it recently. And I hope the Chairman will accept the report of the National Academy of Sciences of July that says the cost of making 20 percent of our electricity from wind power is about the same as making 20 percent of our electricity from nuclear power.

Senator BOXER. Senator, honestly, I do not remember discussing the cost. I was talking about the rate payers' costs.

Senator ALEXANDER. Well, that is who pays for each one.

Senator BOXER. OK.

Senator ALEXANDER. The cost to the rate payer for nuclear, according to the National Academy, is 6 cents to 13 cents over the lifetime per kilowatt hour and 4 cents to 10 cents for wind over its lifetime. And the wind does not include the transmission power or the back-up power. You have to build, you know, natural gas or coal or nuclear plants to back them up because the wind does not blow but a third of the time. And it does not include the taxpayers' subsidy, which over 10 years——

Senator BOXER. I am going to add back a minute to your time because I want to——

Senator ALEXANDER. I just wanted to——

Senator BOXER. No, no. I think this is important.

Senator ALEXANDER. But the rate payers would pay the same.

Senator BOXER. OK. I think it is important to note that taxpayers picked up the bill for the Price-Anderson Act. And that is always forgotten.

Senator ALEXANDER. No, Madam.

Senator BOXER. It is in there.

Senator ALEXANDER. May I correct that? Because——

Senator BOXER. Well, after the certain amount of billions, then the taxpayer is for catastrophic. We know that.

Senator ALEXANDER. Well, each, let me see if I remember right, you have got 104 nuclear reactors, they each are responsible up to the first $10 billion?

Senator BOXER. Ten billion dollars.

Senator ALEXANDER. So, anything above 104 times $10 billion the taxpayer would be responsible for, but the taxpayer takes care of disasters every time we have one of that magnitude.

Senator BOXER. Well, if I could say, it is quite a different situation. But I mean, if you know what happened in Chernobyl, I do not see that happening with wind power.

Senator ALEXANDER. That was in Russia, Madam.

Senator BOXER. Yes, and Three Mile Island——

Senator ALEXANDER. The taxpayer has never paid a penny of——

Senator BOXER. But that is not the issue. The issue is, if we do not have to, why do we not repeal? I will join you in repealing it, because I think that would make it much more attractive to the American people if they did not have to worry about the possibility of a catastrophic——

Senator ALEXANDER. I would do that if you would join me in repealing in the $170 billion subsidy for wind power that we will be paying over 10 years to make 20 percent of our energy.

Senator BOXER. Well, let us talk. I doubt that we will reach a meeting of the minds for a lot of reasons——

Senator ALEXANDER. Probably not.

Senator BOXER. But I have to say, I have to say, really, I think nuclear is going to be part of the mix. And this is the last point. I think what we have argued about more than the cost is that at the end of the day there will be more nuclear plants built under the Kerry-Boxer bill than under your plan to build 100 plants. That is what the studies show.

And for some reason, you continue to make the point that nuclear is the answer when, in fact, in our bill there will be more nuclear plants built under out bill than under your build 100 plants now scenario.

Senator ALEXANDER. Well, my problem with that, Madam Chairman, and I would like to discuss this with you, is that the bill that we are writing here will be combined with the renewable energy bill, which favors wind and excludes nuclear. So, we have a national windmill policy that encourages and subsidizes building windmills, and we have not started a nuclear power plant in 30 years.

Senator BOXER. Well, let us talk about the loan guarantees. You want to talk about that for nuclear? I mean, let us face it——

Senator ALEXANDER. I would like us to have a carbon-free electricity standard——

Senator BOXER. I love it.

Senator ALEXANDER. Where all forms of carbon-free energy would be treated the same.

Senator BOXER. That is fine. That is fine. But you forget, what you forget every time we have this conversation, which I enjoy, is the Price-Anderson Act, you forget about that, you forget about the loan guarantees, you forget about a lot of the things.

I think what we should do, just because it is an intellectual debate, which I think is worthy of our time but probably not now, these poor people. But why do we not sit down and I will make a list of all the Government subsidies that the nuclear industries get, and I will make a list of all that the wind gets——

Senator ALEXANDER. Good.

Senator BOXER. And you do the same.

Senator ALEXANDER. I will.

Senator BOXER. And let us sit down and compare. But at the end of the day, they are both very important to the future here because they are clean, and that is good.

Senator ALEXANDER. And I had included in the record the other day the estimates that over the next, the subsidies for wind are about 10 times that for nuclear, and they are much more than any other form of renewable energy.

But I accept your invitation, and I look forward to doing this. I just wanted to make sure that it was noticed that the rate payers, the cost of wind, according to the National Academy of Sciences, the rate payers would pay about the same in each case.

Senator BOXER. OK, OK.

Senator ALEXANDER. Now, I would also like to include in the record what I think is a pioneering study done by the Nature Conservancy, if I may, Madam Chairman, which is entitled Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural Habitats in the United States of America, and remarks I made on the perils of energy sprawl to the Resources for the Future on October 5, 2009. I would like to include that in the record.

Senator BOXER. Absolutely.

Senator ALEXANDER. The recommendations of the Nature Conservancy paper, I hope, are something this committee would take seriously. They warned that over the next 20 years new energy production, especially biofuels, which we are learning more about, and wind power, will consume a land mass larger than the State of Nebraska, and they made some suggestions for how we might deal with that.

The first insight was the size of the [unclear]. The second was they noted the widely varying amounts of land consumed by different production, for example, in terms of biomass, to equal the production of one nuclear reactor, you would have to continuously forest an area the size of the Great Smoky Mountains with hundreds of trucks running up and down the mountain every day with wood chips.

And in terms of when, I would point out, that a row of 50-story wind turbines along the entire 2,178 mile Appalachian Trial, 50-story wind turbines, would generate the same amount of electricity produced by four nuclear reactors on 4 square miles.

And they suggested site selection was important, talking about the impact on wildlife. To Mr. Schweiger, let me ask you. Have you thought about the renewable energy sprawl and its effect on wildlife? I think some of the State wildlife commissions may have.

And specifically, ExxonMobil pleaded guilty in Federal Court to killing 85 birds that came into contact with crude oil or pollutants that are protected by the Migratory Bird Treaty Act which dates back to 1918. They paid $600,000 in fines.

The wind turbines we have today kills between 75,000 and 275,000 birds a year, according to the Bird Conservancy. If we make 20 percent of our electricity from wind turbines, that would be 1.4 million birds per year. What would be the fine for killing 1.4 million birds per year? At one wind farm near Oakland, California, it estimates that its turbines kill 80 Golden Eagles a year.

Have you thought about that in your Federation, and do you think the Migratory Bird Act ought to apply to other forms of energy production?

Mr. SCHWEIGER. Well, let me answer your first question first. In terms of land use impacts, I think we need to be thoughtful and careful about where we place those systems so that we avoid destroying the fragile ecosystems that are truly important to overall, you know, life on earth. And I think that with some great care going into that, we can do that.

Second, we need to pay very close attention to the types of technology deployed and how they are done. I think there have been vast improvements in wind turbines, and I think we need to continue to develop, you know, approaches that avoid bird strikes and strikes of bats and other things.

Senator ALEXANDER. Do you think the Migratory Bird Treaty Act ought to apply to other forms of energy production?

Mr. SCHWEIGER. Well, I think the Migratory Bird Treaty Act ought to be enforced wherever it is a problem.

Senator ALEXANDER. So, if it kills 1 million birds a year, then who, the wind developers are responsible for that just as oil developers are for——

Mr. SCHWEIGER. I think that we need to be careful of what we are doing with wildlife and make sure that we protect birds as a resource of this country.

I would also point out to you that I spent a week in Prince William Sound where Exxon caused the pollution there, and the oil that they spilled is still there. It just under the sand about 6 of 8 inches and I traveled around with some scientists looking at that over the entire system. So, it continues to still have a tremendous impact on not just birds, but other life as well. I think Exxon got away with a lot.

Senator ALEXANDER. I think the fine was fine. I think they should be fined for killing 85 birds. I was just suggestion that 100 nuclear reactors on 100 square miles might kill fewer birds and disturb less wildlife than 186,000 wind turbines and 19,000 new miles of transmission lines.

Senator BOXER. OK.

Senator Whitehouse.

[The referenced study and remarks follow:]

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PLoS one

Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural Habitat for the United States of America

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Abstract

Concern over climate change has led the U.S. to consider a cap-and-trade system to regulate emissions. Here we illustrate the land-use impact to U.S. habitat types of new energy development resulting from different U.S. energy policies. We estimated the total new land area needed by 2030 to produce energy, under current law and under various cap-and-trade policies, and then partitioned the area impacted among habitat types with geospatial data on the feasibility of production. The land-use intensity of different energy production techniques varies over three orders of magnitude, from 1.9–2.8 km^2/TW hr/yr for nuclear power to 788–1000 km^2/TW hr/yr for biodiesel from soy. In all scenarios, temperate deciduous forests and temperate grasslands will be most impacted by future energy development, although the magnitude of impact by wind, biomass, and coal to different habitat types is policy-specific. Regardless of the existence or structure of a cap-and-trade bill, at least 206,000 km^2 will be impacted without substantial increases in energy efficiency, which saves at least 7.6 km^2 per TW hr of electricity conserved annually and 27.5 km^2 per TW hr of liquid fuels conserved annually. Climate policy that reduces carbon dioxide emissions may increase the areal impact of energy, although the magnitude of this potential side effect may be substantially mitigated by increases in energy efficiency. The possibility of widespread energy sprawl increases the need for energy conservation, appropriate siting, sustainable production practices, and compensatory mitigation offsets.

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Introduction

Climate change is now acknowledged as a potential threat to biodiversity and human well-being, and many countries are seeking to reduce their emissions by shifting from fossil fuels to other energy sources. One potential side effect with this switch is the increase in area required by some renewable energy production techniques [1–5]. Energy production techniques vary in the spatial extent in which production activities occur, which we refer to as their energy sprawl [2,3], defined as the product of the total quantity of energy produced annually (e.g., TW hr/yr) and the land-use intensity of production (e.g. $km^2$of habitat per TW hr/yr). While many studies have quantified the likely effect of climate change on the Earth's biodiversity due to climate-driven habitat loss, concluding that a large proportion of species could be driven extinct [6–8], relatively few studies have evaluated the habitat impact of future energy sprawl. It is important to understand the potential habitat effects of energy sprawl, especially in reference to the loss of specific habitat types, since habitats vary markedly in the species and ecosystem processes they support.

Within the United States, the world's largest cumulative polluter of greenhouse gases, concern over climate change has led to the consideration of a cap-and-trade system to regulate emissions, such as the previously proposed Lieberman-Warner Climate Security Act (S. 2191) [9] and the Low Carbon Economy Act (S. 1766) [10]. Major points of contention in structuring a cap-and-trade system are the feasibility and desirability of carbon capture and storage (CCS) at coal plants, the creation of new nuclear plants, and whether to allow international offset programs that permit U.S. companies to meet obligations abroad [11]. The rules of a cap-and-trade system, as well as technological advances in energy production and changes in the price of fossil fuels, will affect how the U.S. generates energy. In this study we take scenarios of a cap-and-trade system's effect on United States energy production and evaluate each scenario's impact on habitat due to energy sprawl. Our scenarios (Fig. 1A) are based on the Energy Information Administration (EIA) forecast of energy production in 2030 [12] under current law (the "Reference Scenario"), including the renewable fuel standard of the Energy Independence and Security Act of 2007, and under three cap-and-trade scenarios: the "Core Cap-and-Trade Scenario", where the full Lieberman-Warner Climate Change Act is implemented; the "Few Options Scenario", where international offsets are not allowed and where

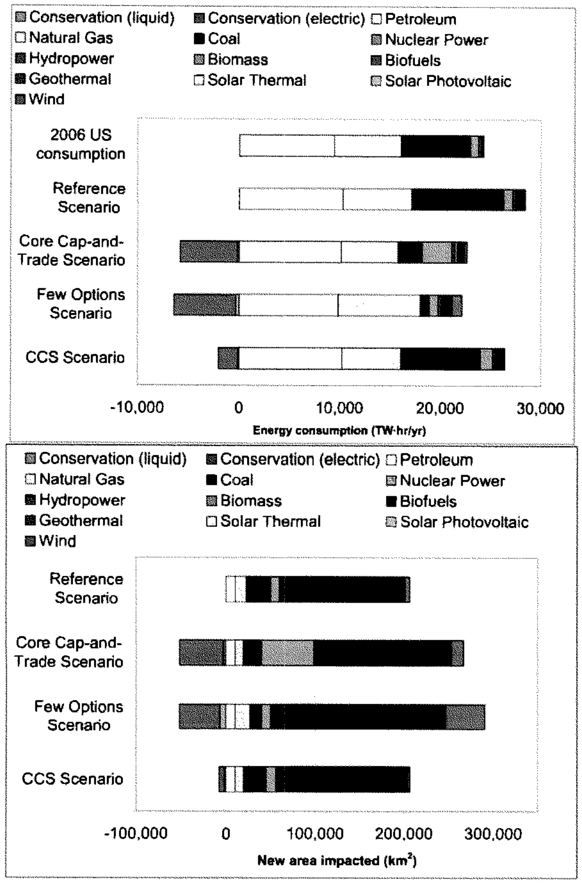

Figure 1. U.S. energy consumption and total new area impacted. (A) U.S. energy consumption in 2006 and under four EIA scenarios. Energy conservation of liquid fuels and electricity, calculated relative to the Reference scenario, are shown as negative since they reduce consumption. (B) The total new area impacted because of development between 2006 and 2030. The new area impacted, or energy sprawl, is a product of consumption and the land-use intensity values in Figure 3. Energy conservation is calculated based on a scenario-specific weighted-average of the energy mix.
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new nuclear production and coal production with CCS are not possible; and the "CCS Scenario", where Congress enacts the Low Carbon Economy Act, a cap-and-trade system more favorable to coal with CCS.

Under each scenario, we first estimate the total new land area in the U.S. needed to produce energy for each production technique as a function of the amount of energy needed and the land-use intensity of production. We examine the effect of U.S. climate policy on future energy sprawl using energy scenarios based on proposed legislation, building on a body of literature on this topic [1,2,13–15]. Note that our analysis focuses only on U.S. land-use implications, ignoring other, potentially significant international land-use implications of U.S. climate policy. Second, we use available information on where new energy production facilities

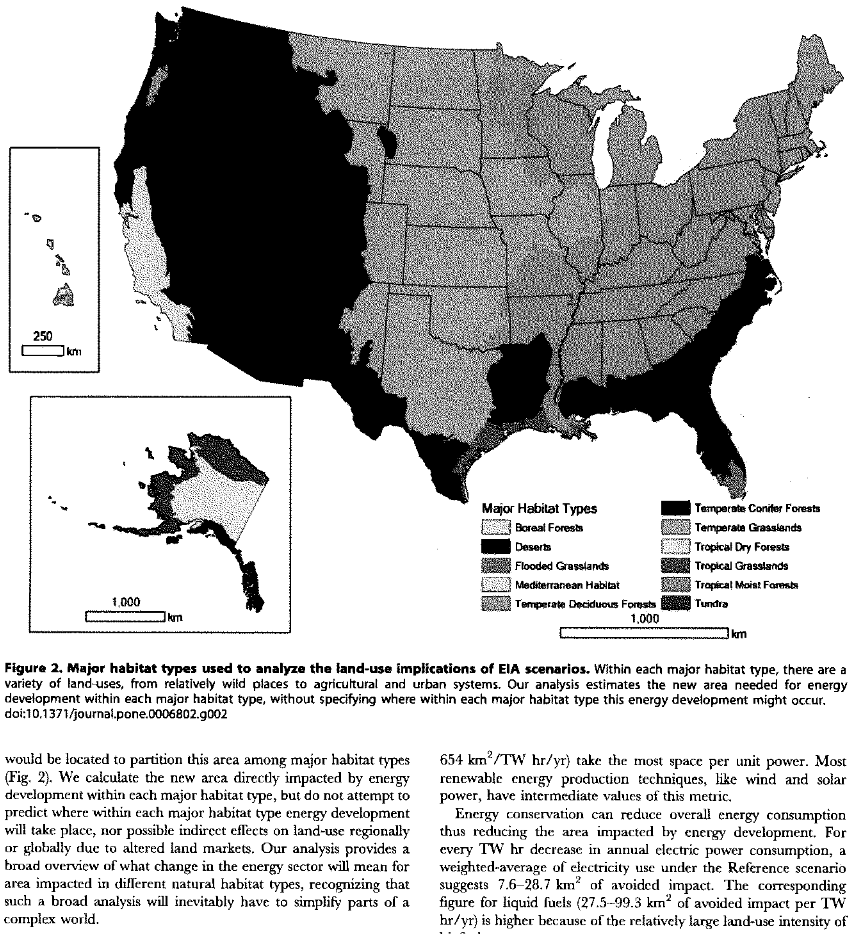

Figure 2. Major habitat types used to analyze the land-use implications of EIA scenarios. Within each major habitat type, there are a variety of land-uses, from relatively wild places to agricultural and urban systems. Our analysis estimates the new area needed for energy development within each major habitat type, without specifying where within each major habitat type this energy development might occur.
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would be located to partition this area among major habitat types (Fig. 2). We calculate the new area directly impacted by energy development within each major habitat type, but do not attempt to predict where within each major habitat type energy development will take place, nor possible indirect effects on land-use regionally or globally due to altered land markets. Our analysis provides a broad overview of what change in the energy sector will mean for area impacted in different natural habitat types, recognizing that such a broad analysis will inevitably have to simplify parts of a complex world.

Results

Land-use intensity of energy production

The land-use intensity of different energy production techniques (i.e., the inverse of power density [16,17]), as measured in km^2 of impacted land in 2030 per terawatt-hour per year, varies over three orders of magnitude (Fig. 3). Nuclear power (1.9–2.8 km^2/TW hr/yr), coal (2.5–17.0 km^2/TW hr/yr) and geothermal (1.0–13.9 km^2/TW hr/yr) are the most compact by this metric. Conversely, biofuels (e.g., for corn ethanol 320–375 km^2/TW hr/yr) and biomass burning of energy crops for electricity (433–654 km^2/TW hr/yr) take the most space per unit power. Most renewable energy production techniques, like wind and solar power, have intermediate values of this metric.

Energy conservation can reduce overall energy consumption thus reducing the area impacted by energy development. For every TW hr decrease in annual electric power consumption, a weighted-average of electricity use under the Reference scenario suggests 7.6–28.7 km^2 of avoided impact. The corresponding figure for liquid fuels (27.5–99.3 km^2 of avoided impact per TW hr/yr) is higher because of the relatively large land-use intensity of biofuels.

Our definition of impact varies among energy production techniques, so a less compact way of generating energy does not necessarily mean that an energy production technique is more damaging to biodiversity, but simply that it has a larger spatial area impacted to some degree. Moreover, many energy production techniques actually have multiple effects on biodiversity, which operate at different spatial and temporal scales. Biodiversity impacts that are likely to scale with areal impact include habitat replacement and habitat fragmentation. Energy production impacts on biodiversity not related to land use intensity include impacts on air quality (e.g. acid rain, particulates), water quality

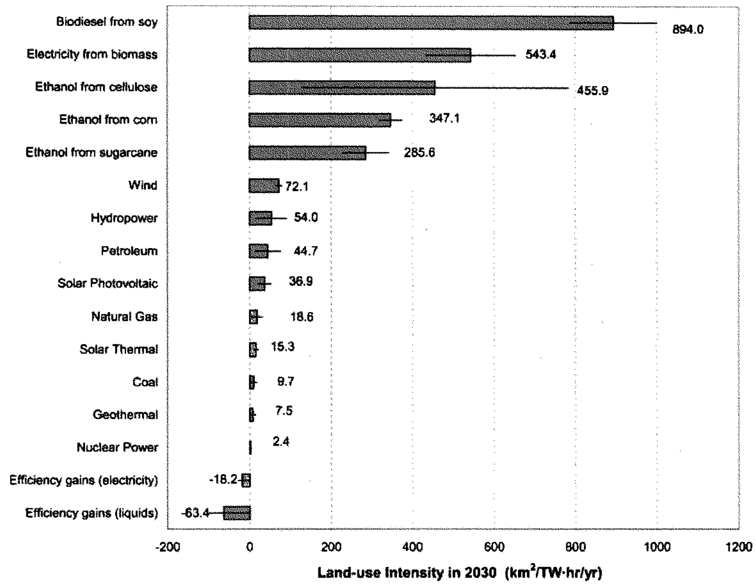

Figure 3. Land-use intensity for energy production/conservation techniques. Value shown is for 2030, as measured in km^2 of impacted area in 2030 per terawatt-hour produced/conserved in that year. Error bars show the most-compact and least-compact estimates of plausible current and future levels of land-use intensity. Numbers provided are the midpoint between the high and low estimates for different techniques. For liquid fuels, energy loss from internal combustion engines is not included in this calculation.
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(e.g. mercury, eutrophication), water consumption (e.g. irrigation water, evaporation from hydroelectric reservoirs), and water flows (e.g. dam-based hydroelectric). Further, the longevity of the impacts described here varies. For example, radioactive nuclear waste will last for millennia, some mine tailings will be toxic for centuries, and other mines may be reclaimed for agriculture within decades.

A full discussion of the impacts on biodiversity of energy production is beyond the scope of this paper, but one fundamental distinction is worth making. Some energy production techniques clear essentially all natural habitat within their area of impact. A review of the literature (see citations below and in Supplementary Text S1) found this to be true for coal, nuclear, solar, and hydropower, as well as for the growth of energy crops for biofuels or for burning for electricity. Energy crop production is a particularly complex situation because even if new energy crop production occurs on land that was previously in agricultural production, remaining global demand for agricultural commodities may spur indirect effects on land-use elsewhere, potentially causing an agricultural expansion in areas far from the location of energy crop production [18]. Other energy production techniques have a relatively small infrastructure footprint and a larger area impacted by habitat fragmentation and other secondary effects on wildlife. A review of the literature found that production techniques that involve wells like geothermal, natural gas, and petroleum have about 5% of their impact area affected by direct clearing while 95% of their impact area is from fragmenting habitats and species avoidance behavior. Wind turbines have a similar figure of about 3–5% of their impact area affected by direct clearing while 95–97% of their impact area is from fragmenting habitats, species avoidance behavior, and issues of bird and bat mortality.

Energy sprawl in 2030

Regardless of climate change policy, the total new area affected by energy production techniques by 2030 exceeds 206,000 km^2 in all scenarios (Fig. 1B), an area larger than the state of Nebraska. Biofuels have the greatest cumulative areal impact of any energy production technique, despite providing less than 5% of the U.S. total energy under all scenarios. Biofuel production, and hence new area impacted, is similar among scenarios because EIA's economic model suggests that, under current law, incentives for biofuel production cause expansion of this energy production technique regardless of climate policy.

Nevertheless, in the scenarios we considered there is a tendency for greater reductions in greenhouse gas emissions to be associated with a greater total new area affected by energy development, particularly under the Core Cap-and-Trade and Few Options Scenario (Figure 4). A decrease in U.S. emissions increases the new area impacted, although the magnitude of the effect is policy

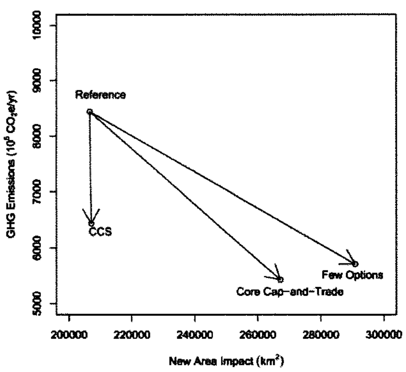

Figure 4. Greenhouse gas emissions and total new area impacted with a cap-and-trade system. Arrows depict the difference between the Reference Scenario, with no cap-and-trade system, and three other scenarios where a cap-and-trade system is implemented. Greenhouse gas emissions measured in million tonnes of carbon dioxide equivalent.
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specific. Under the Core Cap-and-Trade scenario, the burning of energy crops for electricity becomes profitable after the price of electricity rises due to the cap-and-trade system, resulting in a large new areal impact. Similarly, wind power is very important in the Few Options scenario, where new electric production from coal and nuclear is not an option, and causes a large new areal impact. Conversely, in scenarios where there is not control on carbon emissions (Reference Scenario) or in cases where CCS is viable (e.g., CCS Scenario), coal production has a large new areal impact. The infrastructure for CCS is actually a small fraction of the area impacted by coal mining itself, so the major land-use change implication of the viability of coal with CCS is the continuation of coal mining (Supplementary Data S1).

Our results stress the importance of energy conservation for reducing energy sprawl. Relative to the Reference scenario, all cap-and-trade scenarios involve a reduction in energy consumed (Fig. 1B), because of energy efficiency and foregone consumption due to higher energy prices. This energy conservation is primarily in the electricity market, which is more elastic than demand for liquid fuels. Electricity conservation avoids impacts on at least 49,600 km^2 in the Core Cap-and-Trade scenario, while at least 2,500 km^2 will be saved due to liquid fuel conservation, compared to the Reference scenario. EIA assumptions about the potential for energy conservation are relatively modest [19] and some groups argue that energy conservation has greater potential [20].

Habitat impacts

The major terrestrial habitat types (Fig. 2) impacted domestically by energy development varied among energy production technique (Table 1). Regardless of scenario, the major habitat types with the most new area affected, summing over all energy production techniques, are Temperate Deciduous Forests and Temperate Grasslands (Supplementary Data S2). In the Reference scenario, Temperate Deciduous Forests have between 95,000 km^2 (most compact estimate) and 229,000 km^2 (least compact estimate) impacted, while Temperate Grasslands have 65,000–168,000 km^2 impacted. In the Core Cap-and-Trade scenario these types have 119,000–254,000 km^2 and 88,000–191,000 km^2 impacted, respectively. Patterns of total new areal impacts are driven by biofuel production, which peaks in these two habitat types. Biomass burning for electricity and coal mining are also concentrated in Temperate Deciduous Forests and Temperate Grasslands. Wind production onshore is likely to affect Temperate Conifer Forests and Temperate Grasslands in the western U.S. disproportionately. The least impacted habitats are: Tundra; Boreal Forest; Tropical Dry Forests; Flooded Grasslands; and Tropical Moist Forests. All of these habitat types have less than 150 km^2 impacted by energy development in the Reference Scenario and less than 600 km^2 impacted by energy development in the Core Cap-and-Trade Scenario, using the minimal sprawl estimates from Figure 3.

Table 1. Minimum new area (km^2) of habitat types impacted in the U.S.

Habitat Type	Coal	Biomass	Biofuels	Wind
Boreal Forests	94 (−27)	2 (+12)	3 (+0)	6 (+9)
Deserts	2,310 (−662)	257 (+1244)	372 (+14)	884 (+1,300)
Flooded Grasslands	0 (0)	30 (+143)	41 (+1)	0 (0)
Mediterranean Habitat	5 (−1)	123 (+596)	1,699 (+37)	54 (+79)
Temperate Conifer Forests	4,936 (−1,413)	1,883 (+9,106)	12,977 (+739)	2,835 (+4,169)
Temperate Deciduous Forests	10,297 (−2,945)	4,014 (+19,415)	76,841 (+6,751)	428 (+630)
Temperate Grasslands	7,508 (−2,147)	3,760 (+18,185)	46,821 (+4,136)	1,392 (+2,047)
Tropical Dry Forests	0 (0)	4 (+18)	5 (0)	34 (+50)
Tropical Grasslands	1,304 (−373)	59 (+284)	1,583 (+65)	3 (+5)
Tropical Moist Forests	0 (0)	7 (+32)	9 (0)	78 (+115)
Tundra	0 (0)	0 (0)	0 (0)	0 (0)

Data are from the Reference Scenario for four major types of energy development: coal production, biomass burning for electricity, biofuel production, and wind power. Energy development is partitioned among habitat types, as depicted in Figure 2. Numbers in parentheses are the change in value under the Core Cap-and-Trade Scenario. For example, boreal forests have 94 km^2 affected under the Reference Scenario by coal, but have 27 fewer km^2 affected by coal under the Core Cap-and-Trade Scenario (i.e., 67 km^2).
doi:10.1371/journal.pone.0006802.t001

The major habitats impacted by new energy development also varied among scenarios for certain energy production techniques. For example, scenarios where continued coal power generation is viable, either because of no restrictions on carbon emissions (Reference scenario) or because CCS is viable (e.g., CCS scenario) have greater impacts on those major habitat types with major coal seams (e.g., Temperate Deciduous Forests). Conversely, scenarios where coal power generation is less viable have greater production from wind, affecting specific habitat types where those production techniques are favorable (e.g., Temperate Conifer Forests). Climate policy thus controls the extent to which specific habitat types are at risk from new energy development.

Discussion

Our analyses show that, regardless of scenario, at least 206,000 km2 of new land will be required to meet U.S. energy demand by 2030. Further, implementing a cap-and-trade system may increase the total new area impacted by energy development and change its distribution among habitat types, relative to the Reference scenario. Energy production will shift from fossil fuels to energy production techniques that draw more diffuse energy from a broader spatial area. Note that because the EIA analysis assumes that the energy market responds to price signals and does not explicitly attempt to minimize land-use *per se*, it is theoretically possible that there are other, more expensive mixes of energy production that would satisfy U.S. energy needs in 2030 but would take less space. Although policies that reduce carbon emissions with minimal new land use are possible, none of the different policy EIA scenarios we considered were designed with that goal in mind. As shown by Wise et al. [21], if there were financial incentives to minimize land-use in energy production like a tax on greenhouse gas emissions from land-use change, the energy market response to a cap-and-trade might be very different from the response depicted in the EIA scenarios.

There are at least four ways to achieve emissions reduction but avoid the potential side effect of energy sprawl. First, energy conservation can help reduce the new energy needed by the U.S., reducing the area impacted by new energy development. Second, because end-use generation of electricity often occurs on already developed sites, it has minimal habitat impacts, and policy instruments that encourage end-use generation can also decrease the total area impacted. Third, our results suggest that energy sprawl is less severe when the cap-and-trade bill is more flexible, allowing for CCS, new nuclear plants, and international offsets. Fourth, many areal impacts can be mitigated or eliminated with appropriate site selection and planning for energy development. The new area affected by energy development within each major habitat type might, for example, have minimal biodiversity effects if sited in already disturbed places.

The areal impacts on habitat types will vary among scenarios, along with the potential biodiversity impacts of U.S. climate policy. While not all impacts on biodiversity are strictly related to the areal impact, it is likely that energy production techniques with a large areal impact will have a relatively large biodiversity impact. Thus, the details of climate change policy, by favoring particular energy production techniques, pick biodiversity winners and losers. For instance, the Few Options Scenario assumes that international offsets, actions taken abroad to prevent carbon emissions or sequester more carbon, are not allowed under a cap-and-trade regime. The major response forecasted by EIA is an increase in wind production domestically relative to the Reference Scenario, affecting especially Temperate Conifer Forests and Temperate Grasslands. This increase in wind production may be compatible with biodiversity if properly sited, but certainly will pose a challenge for conservationists, because of the large area impacted and the threat of bird and bat mortality [22]. On the other hand, the biodiversity impacts of international offsets are beyond the scope of this paper, but could conceivably be negligible (e.g., scrubber on Chinese coal plant smokestacks), negative (e.g., replacing natural grasslands with plantation forests), or positive (e.g., reducing emissions from degradation or deforestation).

Regardless of whether or not a cap-and-trade system is implemented, the EIA analysis forecasts that biofuels will increase dramatically in importance, with large areal impacts. In the Reference scenario 141,000–247,000 km^2 will be impacted by biofuels. Within the United States much energy crop production will occur on grassland or forest sites already in use for agricultural production, although increased aggregate demand for agricultural commodities may still spur agricultural expansion domestically or internationally (i.e., indirect land-use effects). In part, the large increase in biofuels forecasted by EIA simply reflects their assumption that current law, including the renewable fuel standard defined by the Energy Independence and Security Act of 2007, is maintained to 2030. In part it also reflects the inelasticity of the market for liquid fuels, relative to the electricity market, and the likely high cost of petroleum over the long-term [23]. It seems likely that under current law there will be a large areal impact from biofuels regardless of the cap-and-trade system put in place. Given the high land-use intensity of biofuels, techniques for either increasing the efficiency of biofuel production or making sites of energy crop production more biodiversity-friendly should be a high priority for research.

Our results demonstrate that, under certain policy scenarios, one potential side effect of reducing emissions is an increase in habitat impacts. The impact of a cap-and-trade system will be less, however, than from biofuel production already mandated by current law. Aggressive energy conservation, appropriate siting, sustainable production practices, and reduction of greenhouse gas emissions will all be necessary to minimize the impact of future energy use on habitat and wildlife. Energy sprawl deserves to be one of the metrics by which energy production is assessed.

Materials and Methods

Our analysis proceeded in two phases. First, we calculated the new land area of energy development necessary to meet the EIA scenarios. Not all biodiversity impacts are directly related to the amount of land taken up by a technology, but it is likely that an energy production technique that takes a lot of land will have a relatively large biodiversity impact, so the total new area impact is a useful quantity to measure. Second, we partitioned this new land area among different geographic regions. We focused on domestic impacts for this analysis, ignoring the future habitat impacts of foreign-produced energy, principally future oil imports from Canada, Latin America, and the Middle East, as well as future ethanol imports from Brazilian sugarcane plantations. Similarly, we focused on terrestrial impacts for this analysis, ignoring potential freshwater or marine impacts by hydropower, wind, oil, and natural gas development in U.S. waters. Finally, we are calculating direct land-use (how much land will we need to produce energy?), and did not attempt to estimate secondary changes in the land market in response to the direct land-use.

Scenarios

Our analysis is based on the EIA's 2008 scenarios of energy markets and the economy [12]. These scenarios were calculated by EIA's National Energy Modeling System, a comprehensive econometric model of U.S. energy production, imports, and consumption. The scenarios supply information on the amount of additional energy consumed in 2030 in a particular sector (e.g., million barrels per day of petroleum, billion KW hr of new generation capacity by solar power). We use four scenarios in our analysis. A Reference scenario describes what will likely happen in U.S. energy markets under laws in force as of April 2008. The Core Cap-and-Trade scenario forecasts the effect of the full Lieberman-Warner Climate Security Act (S. 2191), which regulates emissions of greenhouse gases through a cap-and-trade system and provides economic incentives for increased energy efficiency [24]. One variant of S. 2191 is considered, the Few Options scenario, where the use of international offsets in greenhouse gas emissions is either not economically feasible or is severely limited by regulation and where there is no increase in nuclear, coal with CCS, and imports of liquefied natural gas over current levels (the EIA called this the "Limited Alternatives/No International Offsets case"). Finally, the CCS scenario forecasts the effect of the Low Carbon Economy Act (S. 1766), which also sets up a cap-and-trade system for greenhouse gases but offers strong incentives for the development and deployment of CCS [25]. Overall energy consumption by each sector for each scenario is shown in Figure 1A.

Four things about the scenarios are worth noting. First, other scenarios of the likely effect of S. 2191 [11,24] are available from other groups, although they are broadly similar to the EIA analysis. Second, all scenarios of the effect of a cap-and-trade hill are tentative due to uncertainty about the pace of technological change, among other things. Thus, the EIA scenarios we use in this analysis must be taken as indicative of future trends, but not definitive [24]. Third, the EIA scenarios model the likely response of the U.S. energy sector in response to a set of policy assumptions, and do not consider land-use *per se*. The EIA scenarios predict the most likely response, and do not attempt to find a more expensive energy mix that would minimize the total land-use. Finally, U.S. energy policy has changed rapidly since the EIA's 2008 analysis, which still is the most current available full analysis of a cap-and-trade bill. The Warner-Lieberman bill is no longer considered an active bill, and most activity in Congress has focused on the Waxman-Markey bill (H.R. 2454), which proposes a very similar cap-and-trade system. Additionally, the passage of the American Recovery and Reinvestment Bill of 2009 (i.e., the stimulus bill) has provided significant support to renewable energy producers, particularly wind producers. Thus, the Reference Case discussed in this manuscript may underestimate the amount of renewable energy production in that case. Despite these changes in U.S. climate policy since the EIA's 2008 analysis, the broad results of our analysis will likely apply to any similar cap-and-trade system.

Calculating area requirements

Our general strategy was to estimate reasonable most-compact and least-compact values of the amount of area needed to produce a certain amount of energy in a year, the land-use intensity of production. We then multiplied the needed energy by our measurement of land-use intensity of prodnction (km^2/energy/year) to obtain the "energy sprawl," the total new area needed for new energy production in that sector. Calculation of land-use intensity in this manner is useful for the goals of our analysis, allowing calculation of the total new area impacted by energy development. It is similar to the measurement of "area efficiency" [26], in that it does not attempt to account for site preparation prior to energy production nor potential site reclamation after production has ceased, which are sometimes considered in a full life-cycle analysis [3]. Ecologically, over the time period of our study few sites will be reclaimed to vegetation approaching their original habitat value [27]. Numerically, our land-use intensity values represent a lower estimate because they do not include land-use during site preparation or reclamation. While our methodology does not allow a full statistical analysis of the uncertainty of our estimates, the variation between the least compact and most compact estimates of land-use intensity captures most of the uncertainty.

Estimating areal impacts of new methods of electricity generation is relatively straightforward. The EIA forecasts new power generating capacity needed (billion KW), after accounting for likely retirement of existing generation capacity and the nameplate capacity factors of different energy production techniques. We used values from the literature to calculate the km^2 of impact per GW of new generating capacity (see Tables 1, 2, and Supplementary Text S1). Our approach ignores the importation of electricity from Canada or Mexico, on the grounds that this is predicted by the EIA to remain a minor component of total electricity generation. End-use generation of electricity, which is tracked separately for the EIA for several sectors, is considered to have negligible area requirements, since it by definition occurs on previously developed sites. Similarly, the energy efficiency increases in the EIA scenarios are considered to have negligible area requirements, since they occur through upgrades in existing building and infrastructure. We have not

Table 2. Land-use intensity of production for coal mining.

Geographic region	Proportion surface mining	Most compact ha/mmt	Least Compact ha/mmt	Notes
Appalachia U.S.	0.352	11.6 pit, 79.1 surface	115.7 pit, 791.4 surface	Proportion of surface mining from EIA's 2006 Coal production in the United states fact sheet (uses 2003 data). Surface coal yields most compact figure based on Spitzley and Keoleian [3], least compact figure on Flattop mine has 2.3 million tons of coal on 600 acres. Pit mining assumed 10% of area as surface mining.
Interior U.S.	0.643	11.6 pit, 79.1 surface	115.7 pit, 791.4 surface	As above
Western U.S.	0.898	11.6 pit, 79.1 surface	115.7 pit, 791.4 surface	As above
Import	0.671	11.6 pit, 79.1 surface	115.7 pit, 791.4 surface	Proportion surface mining assumed to be same as overall U.S. average.

For each geographic region of coal, we show the proportion of the coal that is from surface mines versus pit mines, as well as least-compact and most-compact estimates of the area requirements of coal mining, in hectares per million metric tonnes of coal. Impact for coal mines is defined as the area directly surrounding the mine site.

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attempted to estimate the new area impacted by new long-distance transmission lines needed to carry new capacity, as the length and location of new lines is very uncertain and depends on future energy production mixes as well as federal and state policy.

Our estimates of land-use intensity of production are shown in Table S1 and Supplementary Text S1. Our large-area estimates are generally from current operating plants, whereas our small-area estimates represent expert opinion about expected future technological advances in efficiency. The definition of impact implied by these estimates was designed to match the majority of published studies of the severity of impact on biodiversity, and thus varies slightly among energy technologies. For example, for hydropower we have assumed that new dam construction inundates an area of terrestrial habitat, removing it of most of its native biodiversity. Note also that the different categories of electricity generation derive from the EIA report. For instance, the EIA chose to recognize solar photovoltaic and electricity from solar thermal as two different energy production techniques, and we follow their convention in our analysis. The EIA partitioned solar photovoltaic use between end-users, assumed to have negligible land-use implications in our analysis, and large-scale generation, which does have significant areal implications. We track end-use and large-scale generation separately in this and other cases, following EIA's methodology.

The EIA forecasts biofuel (ethanol, biodiesel, and other liquids from biomass) production and total use, with the vast majority of use being ethanol in transportation. Moreover, they estimate the proportion of domestic ethanol production from corn, cellulose, and other feedstocks, as well as net imports of ethanol and biodiesel. For each type of biofuel and its feedstock, we estimated least compact and most compact estimates of the number of m^2 of feedstock cropland per liter of biofuel (Table S2 and Supplementary Text S1). In general, least compact estimates are for current agricultural yields (kg/m^2) and biofuel production efficiencies (L/kg), while most compact estimates are a product of future agricultural yields and biofuel production efficiencies. For some crops like soy, the difference in least compact and most compact estimates is primarily due to a predicted increase in yield, while for other biofuels like cellulosic ethanol the difference is largely due to differences in biofuel production efficiency.

For many biofuels, farmers also make a portion of their income from coproducts, portions of the crop that are not used to make biofuels but have another economic market. We use a market-value allocation approach, defining the actual increase in production area of a crop as a function of the fraction of the economic value of the crop that is embodied in the biofuel [28]. Note that our methodology tracks the direct land-use needs of biofuel production, and does not consider indirect effects on land-use via agricultural commodity markets. For example, if a soy field in the U.S. is switched to corn to make ethanol, than soy production will likely expand elsewhere either domestically or internationally. A full accounting of the demand and supply curves of the various agricultural crops, biofuels, and their coproducts is beyond the scope of this project, but is an active area of research [18,29-31].

Estimating the areal impact of fossil fuels was done in an analogous manner. EIA analyses divided domestic coal production into three geographic regions (Appalachia, Interior, and West). We separated the coal produced in each region into the proportion mined underground and the proportion mined at the surface, using EIA's factsheet on coal production in the United States. Then, using data on the amount of coal removed per unit area, we calculated area impacted (Table 2). For this analysis, we ignore the relatively small areal impact of coal burning power plants, which comprise a small fraction of the areal impact of coal mining.

For oil production, the EIA estimated imports as well as domestic production from three geographic regions: the land surface of the contiguous 48 United States (lower 48 onshore); water bodies in or close to the contiguous 48 United States (lower 48 offshore) and the state of Alaska. Note that because EIA assumes existing law will continue, including the ban on new oil drilling in the Arctic National Wildlife Refuge, Alaska oil production actually falls slightly under all scenarios. Based on historical data from the United States Geological Survey (USGS), we estimated the proportion of oil production that is from oil wells (as opposed to incidental production from gas wells) and the average number of barrels per day per development well (Table 3). We also estimated the number of development wells that are abandoned per year. Using these data, we calculated the number of new development wells needed to maintain current production and the number of wells needed to achieve any production increase forecasted by the EIA. By using this approach we are accounting for the tendency of older wells to fall in production over time and be abandoned, necessitating new wells just to maintain current production levels.

For natural gas production the EIA provides one aggregate domestic production figure, but does differentiate between pipeline natural gas imports, which are predicted to decline, and liquefied natural gas imports, which are predicted to increase. Following a similar approach to the petroleum case, we estimated the proportion of gas production that is from gas wells (as opposed to incidental production from oil wells) and the average annual thousand cubic feet per well (Table 3). Methodology generally followed that used for oil wells.

The EIA provides explicit estimates of the emissions avoided (million metric tons of CO_2 equivalent) by the use of CCS

Table 3. Land-use intensity of oil and natural gas production.

Natural Resource	Proportion from well type	Average production	Most compact (ha/well)	Least Compact (ha/well)	Notes
Oil	0.862 from oil wells for onshore production in lower 48, 0.636 for Alaska.	1.14 m^3/day of crude from lower 48 onshore, 56.13 m^3/day of crude from Alaska onshore.	5.67	32.38	See text for estimation of trends in oil production. Pinedale Anticline spacing is taken as most-compact estimate and Jonah field spacing as least-compact estimate.
Natural Gas	0.948 from natural gas wells for U.S. onshore.	2,821 m^3/day of dry natural gas from U.S. onshore.	5.67	32.38	As above.

For each geographic region (lower 48 onshore, lower 48 offshore, and Alaska), we used estimates of the proportion of the resource that is withdrawn from each type of well and average well productivity, as well as least-compact and most-compact estimates of the area affected by each well, in hectares per well. Impact for wells is defined as both the well area and the surrounding habitat fragmented by wells, access roads, and other structures. See text for details on impact calculations of oil and gas pipelines.

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technology, relative to a 2006 baseline, for three sectors of electricity generation (petroleum, natural gas, and coal). Because of the EIA assumptions about the cost-effectiveness of implementation of CCS and the incentive structures in S. 2191 and S. 1766, power plants burning petroleum for electricity do not generally implement CCS, whereas power plants burning natural gas or coal do whenever there is a carbon cap in place (i.e., not the Reference scenario) and when the CCS technology is available (i.e., not the Few Options case).

For new petroleum and natural gas production, we estimated the amount of new pipeline needed, based on current ratios of kilometers of pipeline to wells, assuming that these ratios held constant into the future (0.9 km/well for oil production, 1.3 km/well for gas production). For CCS, we also estimated the new pipelines needed to move CCS (0.5 km/well): the length of new pipeline per CCS injection site is likely to be more limited than in the petroleum or natural gas case because CO_2 has little economic value [32]. For all pipelines, we then estimated the area impacted on either side of the pipe (most-compact estimate 0.3 ha/km of pipe, least-compact estimate 1.8 ha/km of pipe, based on common right of ways of pipelines). By estimating the area impacted by pipelines in this way, we are assuming that the process of pipeline construction removes most native biodiversity, and that any revegetation after pipeline construction will have minimal biodiversity value.

A literature review revealed that many energy production techniques actually have multiple effects on biodiversity, which operate at different spatial and temporal scales. A full discussion of the impacts on biodiversity of energy production is beyond the scope of this paper, but we recorded quantitative data on the proportion of our defined impact zone that was directly affected by land clearing, as opposed to more diffuse processes such as habitat fragmentation and organism avoidance behavior. Studies with useful quantitative or semi-quantitative data on this topic include: Coal [33], Nuclear [34–37], Solar [38,39], Hydroelectric [40,41], Biofuels [5,18,28–31,42], Geothermal [43], Natural Gas and Petroleum drilling [44,45], and Wind [22,46–51].

Where energy development occurs

The goal of this phase of the analysis was to partition the total area of new energy development among geographic regions. We ignored energy production techniques that had no significant cumulative areal impact as calculated above (i.e., end-use power generation, energy efficiency gains). For our regionalization analysis, we chose definitions of geographic regions that have maximal relevance to biodiversity yet are coarse-scaled enough to average over errors and uncertainty in more fine-scaled input data on energy resource availability and demand. For terrestrial impacts we used the 11 major habitat types of the United States, as defined by Nature Conservancy ecoregions [52–54]. For each major habitat type, we estimate the total area of new energy development, without attempting to specify where within each major habitat type development will take place. Within each major habitat type, there are a variety of land-uses, from relatively wild places to agricultural and urban systems. Thus specific siting decisions, while outside the scope of our analysis, will be important in determining actual biodiversity impact.

Throughout our analysis, we excluded certain areas as being protected or restricted from development, modeling our decision rules on those used in the Department of Energy's report "20% Wind Energy by 2030 [47]." We excluded areas that were protected areas with a Gap Analysis Program code of 1 or 2 (i.e., permanent protection excluding development), based on the Protected Area Database of the United States, version 4[55]. We also excluded airports, urban areas, and wetlands/water bodies from development, based on vector layers included with Environmental Systems Research Institute's (ESRI) ArcGIS package. Areas with an average slope greater than 20% were also excluded, based on a surface analysis of the GTOPO global digital elevation model [56]. Finally, for wind power we assumed that areas within 3 km of an airfield or urban area were not developable.

For each energy production technique, we partitioned its land use among regions in one of two methods. For some energy production techniques, continuous (i.e., interval or ratio scale) estimates of the supply of that resource were available for different geographic regions (Table S3 and Supplementary Text S1). For example, the Department of Energy publishes a continuous estimate of the water power potential in MW of the different hydrologic regions of the United States [57]. In these cases with continuous estimates of resource supply, we assumed that the area of energy development in each geographic region was proportional to the total supply in that region. For some resources, the geographic units in which data was available did not match those of our analysis units, and we used geographic information system (GIS) analyses to partition the resource among habitat types, making the simplifying assumption that the resource was evenly distributed within the original geographical units of the data. To give an example from one particularly dataset, potential biomass estimates were available from the National Renewable Energy Laboratories (NREL), summarized per county [58]. We calculated tonnes/km^2 for each county, digitized the data to a 1 km raster resolution of the United States, and then used ESRI ArcGIS ZonalStatistics commands to sum up the total available biomass in each of our major habitat types.

Other energy production technologies had data on the supply of the resource that were categorical (i.e., ordinal scale). For example, NREL wind power maps rank sites on a scale of 1 to 7, based on the quantity of wind available as well as its consistency. In these cases with categorical data, we reclassified the U.S. into Excellent, Good, and Poor regions for development of that energy resource. In some cases a continuous estimate of a proxy for a resource was available rather than a direct estimate of power availability, and in these cases we classified the resource into categorical categories based on published opinion about what sites were developable. While our decision rules are admittedly arbitrary, they are derived from common GIS analysis for site selection in the energy industry, and we believe any reasonable set of decision rules would provide qualitatively similar results. In general, we looked at both the supply of a particular resource (e.g., how much sunlight is there?) and the demand (e.g., how far away is the nearest electric transmission line to carry the power to market?). The specific criteria we use are listed in Table S3. We then calculated how much of each geographic region was in the three categories (Excellent, Good, and Poor) using ESRI ArcGIS ZonalStatistics commands. Next, we assumed that the area of energy development in each geographic region was proportional to the area classified as Excellent in that region. If all areas categorized as Excellent were developed without meeting the total areal target, the remaining development was assumed to "spill-over" to the Good category, where it was similarly divided among geographic regions.

Supporting Information

Table S1 Land-use intensity of production for new electricity generation capacity.
Found at: doi:10.1371/journal.pone.0006802.s001 (0.04 MB DOC)

Table S2 Land-use intensity for new biofuel production.

Found at: doi:10.1371/journal.pone.0006802.s002 (0.04 MB DOC)

Table S3 Decision criteria for classifying land.
Found at: doi:10.1371/journal.pone.0006802.s003 (0.05 MB DOC)

Text S1 Technical Citations for Tables S1-S3
Found at: doi:10.1371/journal.pone.0006802.s004 (0.03 MB DOC)

Supplementary Data S1 Detailed data on total U.S. area impacted (km^2) by each energy sector
Found at: doi:10.1371/journal.pone.0006802.s005 (0.02 MB XLS)

Supplementary Data S2 Detailed data on the area (km^2) of U.S. habitat types affected by each energy sector
Found at: doi:10.1371/journal.pone.0006802.s006 (0.04 MB XLS)

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Author Contributions

Designed the project, completed portions of the analysis, and wrote the paper: RIM. Analyzed biofuel and biomass trends: JF. Analyzed trends in oil and natural gas exploration: JK. Analyzed trends in solar power generation: WM. Designed the project: JP.

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The Perils of "Energy Sprawl"

Remarks by U.S. Senator Lamar Alexander

Resources for the Future

October 5, 2009

First, I would like to thank Congressman Phil Sharp and Resources for the Future for organizing this forum and to salute your leadership, especially in coordinating the recent Outdoor Resources Review Group's report recommending permanent funding for the Land and Water Conservation Fund.

Last week I spent several hours watching Ken Burns' film on our national parks and reading Douglas Brinkley's new book, The Wilderness Warrior: Theodore Roosevelt and the Crusade for America. Doing this reminded me that the men and women we honor today in the conservation movement and who founded most of the organizations you represent were not always so honored when they first spoke up. Many of those who spent the last century protecting our landscapes, air and water, and wildlife habitats were once regarded as trivial, eccentric, or went unnoticed. John Muir was an obscure hermit when he began to "preach nature like an apostle." To some, Roosevelt must have seemed a little daffy when he declared he would protect pelicans and warned a country enamored with Manifest Destiny that we should "keep nature unmarred." Lyndon Johnson made jokes about Lady Bird Johnson running around the White House, as he would say, "protecting flowers" with Laurance Rockefeller. But today we honor these and many others for having had the wisdom and the courage to recognize that preserving our natural heritage is essential to the

American Character. Italy may have its art, India its Taj Mahal, but we have the Great American Outdoors.

I believe that a new Nature Conservancy scientific paper, titled, "Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural Habitat for the United States of America," will one day occupy a place among the pioneering actions that we honor in the conservation movement. The paper warns that during the next 20 years new energy production, especially biofuels and wind power, will consume a land mass larger than the state of Nebraska. This "energy sprawl," as the authors termed it, will be the result of government cap and trade and renewable mandate proposals designed to deal with climate change. The paper should serve as a Paul Revere ride for the coming renewable energy sprawl. There are negative consequences, as well as positive effects, from producing energy from the sun, the wind and the earth. And, unless we are as wise in our response as the authors have been in their analysis, our nation runs the risk of damaging the environment in the name of saving the environment.

The first insight in the Nature Conservancy paper is in describing the sheer size of the sprawl. The second insight is in carefully estimating the widely varying amounts of land consumed by different kinds of energy production. Finally, the paper suggests four ways to reduce carbon emissions while minimizing the side effects of energy sprawl on the landscape and wildlife habitat. The first recommendation is energy conservation. Second is generating electricity on already developed sites, as when solar panels are put on rooftops or when a chemical company uses byproducts from its production processes to make heat and power. The third recommendation is to make carbon regulation flexible enough to allow for coal plants that recapture carbon or nuclear power plants that produce no carbon or for international offsets. Fourth, the paper suggests careful site selection.

This makes me think of my own experience as Governor 25 years ago when Tennessee banned new billboards and junkyards on a highway over which 2 million visitors travel each year to the Great Smoky Mountains National Park. Then, that decision attracted little attention. Today, it helps to preserve one of the most attractive gateways to any national park. But, as all of us know, if the billboards had gone up then, it would be almost impossible today to take them down today. The same will be true with wind turbines, solar thermal plants, and other new forms of energy production.

My purpose here today is to challenge you and the organizations who have traditionally protected our landscape, air and water and wildlife habitat to do the same with the threat of energy sprawl. To ask you, first, to suggest to governments and policy makers and landowners before it is too late the best choices and the most appropriate sites for low-carbon or carbon-free energy production. And, second, I want to ask you to do something that gives many conservationists a stomach ache whenever it is mentioned--and that is to rethink nuclear power, because as the Nature Conservancy's paper details, nuclear power in several ways produces the largest amounts of carbon-free electricity with the least impact.

I learned a long time ago that it helps an audience to know where a speaker is coming from. Well, I grew up hiking and camping in the Great Smoky

Mountains where I still live two miles from the park. As a Senator I have fought for strict emission standards for sulfur, nitrogen, and mercury because many of us still breathe air that is too polluted. I have introduced legislation to cap carbon from coal plants because I believe that human production of carbon contributes to global warming. I have helped to create 10,000 acres of conservation easements adjacent to the Smokies because it preserves views of the mountains and wildlife needs the space. I drive one of the first plug-in electric hybrid cars because I believe electrifying half our cars and trucks is the quickest way to clean the air, keep fuel prices down, reduce foreign oil use and help deal with climate change. And I object to 50-story wind turbines along the Appalachian Trail for the same reason I am co-sponsor of legislation to end the coal mining practice called mountaintop removal—not because I am opposed to coal plants or wind power in appropriate places, but because I want to save our mountaintops.

* * *

Let me offer a few examples to paint a clearer picture of what this energy sprawl might look like in 20 years.

As the Nature Conservancy paper notes, most new renewable electricity production will come from wind power which today provides about 1.5 percent of our country's electricity. Hydroelectric dams produce about 7 percent of our electricity and some of them are being dismantled. Solar and all other forms of renewable electricity produce less than 1 percent today. President Bush first suggested that wind power could grow from 1.5 percent to 20 percent by 2030 and President Obama has set out enthusiastically to get this done. In fact, the combination of presidential rhetoric, taxpayer subsidies and mandates have very nearly turned our national electricity policy into a national windmill policy.

To produce 20 percent of America's electricity from wind turbines would require erecting 186,000 1.5-megawatt wind turbines covering an area the size of West Virginia. According to the American Wind Energy Association, one megawatt of wind requires about 60 acres of land, or in other words, that's one 1.5 megawatt wind turbine every 90 acres. These are not your grandmother's windmills. They are 50 stories high. Or, if you are a sports fan, they are three times as tall as the skyboxes at the University of Tennessee football stadium. The turbines themselves are the length of a football field, they are noisy and their flashing lights can be seen for up to twenty miles. In the eastern U.S., where the wind blows less, turbines would work best along scenic ridge tops and coastlines. National Academy of Sciences says up to 19,000 miles of new high voltage transmission lines that would be needed to carry electricity from 186,000 wind turbines in remote areas to and through population centers.

So many wind turbines can create real threats to wildlife. The Governor of Wyoming has expressed concern about protecting the Sage Grouse's diminishing population in his state as a result of possible habitat destruction from wind farms. The American Bird Conservancy estimates that each wind turbine in this country kills as many as seven or eight birds each year. Multiply that by 186,000 wind turbines and you could predict the annual death of close to 1.4 million birds per year. Then there are the solar thermal plants, which use big mirrors to heat a fluid and which can spread over many square miles. Secretary of Interior Ken Salazar recently announced plans to cover 1,000 square miles of federally owned land in Nevada, Arizona, California, Colorado and New Mexico and Utah with such solar collectors to generate electricity. Senator Dianne Feinstein of California, who has spent most of her career trying to make the Mojave desert a national monument, strongly objected to a solar thermal plant in the desert on federal land just outside the Mojave National Preserve that would have covered an area 3 miles by 3 miles. Plans for the plant were recently canceled.

The only wind farm in the southeastern United States is on the 3,300 foot tall Buffalo Mountain in Tennessee. The wind there blows less than 20 percent of the time making the project a commercial failure. Because of the unavailability of wind power, renewable energy advocates suggest that we southeasterners use biomass, a sort of controlled bonfire that burns wood products to make electricity. Biomass has promise, to a point. Paper mills can burn wood byproducts to make energy. And clearing forests of dead wood and then burning it not only produces energy but can help to avoid forest fires. According to the Conservancy's paper, biofuels and biomass burning of energy crops for electricity take the most space per unit of energy produced. For example, the Southern Company is building a new 100 megawatt biomass plant in Georgia. Southern estimates it will keep 180 trucks a day busy hauling a million tons of wood a year to the plant. One hundred megawatts is less than one-tenth the production of a nuclear plant which will fit on one square mile. To produce the same amount of energy as one nuclear plant would require continuously foresting an area one-third larger than the 550,000 acre Great Smoky Mountain National Park. You can make your own estimate of the number of trucks it would take to haul that much wood.

That is the second important insight of the Nature Conservancy report: a careful estimate of the widely different amounts of land each energy-producing technique requires. The gold standard for land usage is nuclear power. You can get a million megawatt hours of electricity a year—that's the standard unit the authors chose—per square mile, using nuclear power. The second most compact form of energy is geothermal energy. To generate the same amount of power, coal requires four square miles, taking into account all the land required for mining and extraction. Solar thermal takes six square miles. Natural gas takes seven square miles and petroleum seventeen. Photovoltaic cells that turn sunlight directly into electricity require 14 square miles and wind is even more dilute, taking 28 square miles to produce the same unit of electricity.

These differences in land use are pronounced even though the paper's analysis is conservative. The authors include upstream inputs and waste disposal as part of their estimate of an energy producer's footprint. They add uranium mining and Yucca Mountain's 220 square miles to the area our 104 nuclear reactors actually occupy. If one were to consider only each energy plant's footprint, to produce 20 percent of U.S. electricity would take 100 nuclear reactors on 100 square miles or 186,000 wind turbines on 25,000 square miles. Visualize the difference this way. Thru hikers regularly travel the 2,178 miles of the Appalachian Trail from Springer Mountain in Georgia to Mount Katahdin in Maine. A row of fifty story wind turbines along that entire 2,178-mile trail would generate the same amount of electricity produced by 4 nuclear reactors on four square miles.

So, because of these wide differences, policy makers have the opportunity to choose carefully among the various forms of producing carbon-free electricity as well as to think about where such energy production should or should not go.

These are the four ways that the Nature Conservancy suggests we approach those decisions:

First, focus on energy conservation. This is the paper's preferred alternative to energy sprawl - and it is hard to see how anyone could disagree. To cite just one example, my home state of Tennessee leads the nation in residential per capita electricity use. If Tennesseans simply used electricity at the national average, the amount of electricity we would save each year would equal that amount produced by two nuclear power plants. Oak Ridge National Laboratory scientists have said that fuel efficiency standards are the single most important step our country can take to reduce carbon emissions.

The second recommendation for dealing with energy sprawl is end-use generation of electricity which usually occurs on already developed sites. One example of this is the co-generation that occurs at a paper factory that uses waste product to produce electricity and heat to run its facility. The most promising example is likely to be solar power on rooftops. In other words, since rooftops already exist, covering them with hundreds of square miles of solar panels would create no additional sprawl. There still are obstacles to the widespread use of solar power. In the southeast, solar still costs 4-5 times what TVA pays on the average for other electricity. There is the obstacle of aesthetics. But companies are now producing solar film embedded within attractive roofing materials—

although this costs more. And there still is the problem that solar power is only available when the sun shines and, like wind, it can't be stored in large quantities. But unlike wind, which often blows at night when there is plenty of unused electricity, the sun shines when most people are at their peak power use. As former Energy Secretary James Schlesinger wrote in the Washington Post, because of their intermittency, wind and solar systems have to be backed up by other forms of electricity generation – which adds to cost and land usage.

The third recommendation is to make carbon regulation flexible, allowing for carbon recapture at coal plants, for nuclear power and for international offsets. So far the sponsors of climate and energy bills in the Congress haven't heeded this advice. In fact, both the Waxman Markey bill in the House and the Bingaman energy bill in the Senate contain very narrowly defined "renewable electricity" mandates. Instead of allowing states to choose their methods of producing the required amount of carbon-free electricity, the legislation heavily tilts toward requiring wind power. For example, the legislation allows existing and new wind turbines, but only new hydroelectric. It does not count nuclear power, municipal solid waste, or landfill gas as "renewable." In the same way, 75 percent of the so-called "renewable electricity" subsidies enacted since 1978 have gone to wind developers. A study by the Energy Information Administration shows that wind gets a subsidy 31 times that of all other renewables combined. These policies have created a heavy bias toward the form of renewable electricity—wind power—that could consume our treasured mountaintops and can be very destructive to wildlife. And a national policy that also encourages wind power in the southeast where the wind barely blows makes as much sense as mandating new hydroelectric dams in the western desert where there is no water. It is my opinion that if we are truly seeking to reduce our carbon output, the policy that would create the least energy sprawl would would be a "carbon-free electricity standard," allowing for the maximum flexibility for those renewable electricity techniques that consume less land and require fewer new transmission lines.

Finally, the Nature Conservancy suggests paying attention to site selection for new energy projects. This is where those of you who represent organizations who have spent a century protecting wildlife and treasured landscapes could be of the greatest help in asking the right questions and providing wise answers. For example, should energy projects be placed in National Parks? In National Forests? If so, which forests and which energy projects? Should there be generous taxpayer subsidies for renewable energy projects within 20 miles of the Grand Tetons or along the Appalachian Trail? What about the large amounts of water needed for solar thermal plants or nuclear plants? Should turbines be concentrated in shallow waters 20 miles or more offshore where they can't be seen from the coast and transmission lines run underwater? Couldn't turbines be located in the center of Lake Michigan instead of along its shoreline? Should there be renewable energy zones, such as the solar zones Secretary Salazar is planning, where most new projects are placed—and where are the most appropriate locations for those zones and their transmission lines? In a recent op ed in the New York Times, the Massachusetts Secretary of Energy and Environmental Affairs asked, wouldn't it make more sense to place wind turbines offshore in the Atlantic and run transmission lines underwater than to build new transmission lines to carry wind power from the Great plains to Boston? Should the subsidies for cellulosic ethanol be larger than those for corn ethanol, or should there be no subsidies at all? Should there be a special effort to encourage conservation easements on private lands that protect treasured viewscapes and habitats?

According to the *Wall Street Journal*, on August 13 Exxon Mobil pleaded guilty in federal court to killing 85 birds that had come into contact with crude oil or other pollutants in uncovered tanks of waste-water facilities on its properties. The birds were protected by the Migratory Bird Treaty Act, which dates back to 1918. The company paid $600,000 in fines and fees.

Should the Migratory Bird law be enforced against developers of other energy projects – for example, renewable electricity and transmission lines? One wind farm near Oakland California estimates that its turbines kill 80 golden eagles a year. The American Bird Conservancy estimates that the 25,000 wind turbines in the United States kill between 75,000 and 275,000 birds per year. "Somebody is getting a get out of jail card free," Michael Fry of the Bird Conservancy told the *Journal*. And what would be the fine for the almost 1.4 million birds that 186,000 turbines might kill?

This raises the question of whether there should be some parity among all energy companies in the application of laws and policies. For example, oil and gas companies receive taxpayer subsidies but they bid to lease and drill on federal land or waters and then pay a royalty for the privilege. Should taxpayer subsidized renewable energy companies also be required to pay a royalty for the privilege of producing electricity on federal lands or waters? And, if so, could this be a source of permanent funding for the Land and Water Conservation fund or other conservation projects on the theory that if the law allows an environmental burden it ought to require an environmental benefit? Based on estimates from the Joint Committee on Taxation and the Congressional Budget Office, taxpayers will pay wind developers a total of $29 billion in federal subsidies over the next 10 years to increase windpower production from 1.5 to 4 percent of our total electricity.

There are an estimated 500,000 abandoned mines in our nation, 47,000 in California alone. To date, Congress has allocated a total of about $4 billion for their cleanup and the end of the cleanup is nowhere in sight. Would it not be wise before the energy sprawl occurs to require bonds on federal lands for the removal of energy equipment that is not used anymore? Wind turbines wear out in 20-25 years. Solar thermal farms can cover hundreds of acres. Policies, subsidies and prices can change. In Germany, for example, a prominent maker of solar equipment recently suggested cutting the government subsidy for solar equipment because it is permanently raising prices of German-made products and Germans are buying cheaper panels made in China. In other words, the Germans are subsidizing Chinese manufacturing. If the large U.S. subsidies for wind power were to disappear—as was promised when they were created—it might be a good idea if someone were required to take away any abandoned equipment.

* * *

This brings me to my last point, which is to ask you to rethink nuclear power.

In our country, fears about safety, proliferation, and waste disposal have stymied the "atoms for peace" dream of large amounts of low-cost clean reliable energy from nuclear power. Twelve states even have moratoria against building new nuclear plants. Still, the 104 U.S. reactors built between 1970 and 1990 produce 19 percent of America's electricity and, as I have said, *70 percent of our carbon-free electricity.* I believe that what Americans should most fear about nuclear power is this: the rest of the world will use it to create low-cost, carbon-free electricity while we—who invented the technology—will not. That would send our jobs overseas looking for their cheap energy. And it would deprive us of the technology most likely to produce large amounts of carbon free electricity to help deal with climate change—and to do it in the way least likely to harm the landscape and wildlife habitat.

Look at what the rest of the world is doing. Of the top five greenhouse gas emitters, who together produce 55 percent of the carbon in the world, only the U.S. has no new nuclear plants under construction. China, the world's largest carbon emitter, recently upped its goal for nuclear reactors to 132. Russia, the number three emitter, plans two new reactors every year until 2030. Of the next two emitters, India has six reactors under construction and ten more planned. Japan already has 55 reactors, gets 35 percent of its electricity from nuclear, has two under construction and plans for ten more by 2018.

According to the International Atomic Energy Agency (IAEA), worldwide there are 53 reactors under construction in 11 countries, mostly in Asia. South Korea gets nearly 40 percent of its electricity from nuclear and plans another eight reactors by 2015. Taiwan gets 18 percent of its power from nuclear and is building two new reactors.

In the West, France gets 80 percent of its electricity from nuclear and has among the lowest electricity rates and carbon emissions in Western Europe (behind Sweden and Switzerland which are both half nuclear.) Great Britain has hired the French electric company EDF to help build reactors. Italy has announced it will go back to nuclear.

So where does this leave the United States? Well, we still know how to run reactors better than anyone else; we just don't build them anymore. Our fleet of 104 plants is up and running 90 percent of the time. We have 17 applications for new reactors pending before the Nuclear Regulatory Commission but haven't started construction on any new ones - and the 104 we currently have in operation will begin to grow too old to operate in twenty years.

That is why I believe the U.S. should build 100 new nuclear plants in 20 years. This would bring our nuclear-produced electricity to more than 40 percent of our total generation. Add 10 percent for hydroelectric dams, 7-8 percent for wind and solar (now less than 2.5 percent together), 25 percent for natural gas (which is low-carbon) and you begin to get a real clean—and low-cost-- electricity policy.

According to the National Academy of Sciences, construction costs for 100 nuclear plants are about the same as for 186,000 wind turbines. New reactors could be located mostly on sites with existing reactors. There would be little need for new transmission lines. Taxpayer subsidies for nuclear would be one-tenth what taxpayers would pay wind developers over 10 years. As for so called "green jobs", building 100 nuclear plants would provide four times as many construction jobs as building 186,000 turbines. And, of course, nuclear is a base load source of power operating 90 percent of the time, the kind of reliable power that a country that uses 25 percent of the energy in the world must have. Wind and solar are useful supplements but they are only available, on average, about one-third of the time and can't be stored in large amounts.

And what about the lingering fears of nuclear? Obama Administration Energy Secretary Dr. Steven Chu, the Nobel Prize winning physicist, says nuclear plants are safe and he wouldn't mind living near one. That view is echoed by the thousands of U.S. Navy personnel who have lived literally on top of nuclear reactors in submarines and Navy ships for 50 years without incident. The Nuclear Regulatory Commission agrees and its painstaking supervision and application process is intended to do everything humanly possible to keep our commercial fleet of reactors safe.

On the issue of waste, Dr. Chu says there is a two step solution. Step one is store the waste on site for 40 to 60 years. The Nuclear Regulatory Commission agrees this can be done safely, perhaps even for 100 years. Step two is research and development to find the best way to recycle fuel so that its mass is reduced by 97 percent, pure plutonium is never created, and the waste is only radioactive for 300 years instead of 1 million years.

That kind of recycling would take care of both the waste and the third fear of nuclear power, the threat that other countries might somehow use plutonium to build a bomb. One could argue that because the U.S. failed to lead in developing the safe use of nuclear technology for the last 30 years, we may have made it easier for North Korea and Pakistan to steal or buy nuclear secrets from rogue countries.

*　　　*　　　*

Now, let me conclude with this prediction: taking into account these energy sprawl concerns, I believe the best way to reach the necessary carbon goals for climate change with the least damage to our environment and to our economy will prove to be (1) building 100 new nuclear plants in 20 years, (2) electrifying half the cars and trucks in 20 years; we probably have enough unused electricity to plug these vehicles in at night without building one new power plant; (3) putting solar panels on our rooftops. To make this happen, the government should launch mini-Manhattan projects like the one we had in World War II: for recycling used nuclear fuel, for better batteries for electric vehicles, to make solar panels cost competitive, and in addition, to recapture carbon from coal plants. This plan should produce the largest amount of electricity with the smallest amount of carbon at the lowest possible cost thereby avoiding the pain and suffering that comes when high-cost energy pushes jobs overseas and makes it hard for low-income Americans to afford their heating and cooling bills.

My fellow Tennessean Al Gore won a Nobel Prize for arguing that global warming is the inconvenient problem. If you believe he is right, and if you are also concerned about energy sprawl, then I would suggest that nuclear power is the inconvenient solution.

*   *   *

Lamar Alexander is Tennessee's senior republican Senator. He is chairman of the Conference of Republican U.S. Senators and a member of the Environment and Public Works Committee.

Senator WHITEHOUSE. Thank you, Madam Chair. I was impressed by the examples of the effects that Dr. Frumhoff gave us of, essentially the effects that already underway, as a result of what we have already released.

And by your testimony, Mr. Schweiger. Your testimony was backed by a considerable number of hunters and fishermen. And I was wondering if you had any specifications at this point of which games species, or which game species habitats, would be most immediately affected, and what sort of hunters or fishermen are at greatest risk of having their, you know, the habitats that they go out and hunt and fish in, compromised in some way, and how soon all of that is going to happen? When will we see the leading edge of that and where?

Mr. SCHWEIGER. Well, that is a great question. I think we are already seeing the leading edge of it. For example, if you look at the natural range of brook trout in the Appalachians, you will see that the southern half of the Appalachians have lost a lot of their original brook trout habitat and that habitat that remains is not in good shape. It is rated moderate to poor where at one time it was actually good habitat, and it had vibrant brook trout.

So, when you look at the brook trout range, it goes into Pennsylvania and New York. Most of that south of Pennsylvania and New York is in bad shape. North of mid-State New York it is in better shape. So, you see it. It is compounding from the southern Apps going north.

The other example I use in my book is the pronghorn antelope. You know, there is a study now from the University of Oregon that suggests that if we continue doing what we are doing now, we will see the sage brush step habitats contracted to a few counties in Wyoming over the next several decades. And if that happens, pronghorn antelope becomes a remnant population in a very small place.

Senator WHITEHOUSE. Thank you.

Mr. Young, your testimony is particularly important to somebody like me from a coastal State. As you have suggested, many of water and wastewater treatment facilities are at the coastline and at risk.

We have seen estimates from the Environmental Protection Agency that the current deficit of water and wastewater infrastructure in this country is $662 billion, I think between now and 2019, if I remember the year correctly. I assume that, at least to your knowledge, these additional liabilities of plants at risk either from storm surge or sea level rise would be in addition to that built-in cost. Do you know that?

Mr. YOUNG. Yes. That is absolutely correct. And the only range of numbers is given as an opportunity, and it is further described in details by regions of the United States in the report. But depending on the timeframe in which you actually do address the problems, whether you wait until it is longer into the impacts of the climate change or whether you begin a proactive program to start earlier.

Senator WHITEHOUSE. One of the reasons I mention that, just peripherally, is that we have a very severe unemployment problem and at the same time a water and wastewater deficit, and one would think we could bring those two together and start building out our water and wastewater infrastructure now while we need the jobs. But I do not necessarily think that is for this committee and this hearing right now.

My last question will be to Dr. Frumhoff from the Union of Concerned Scientists. This will be a question about the science of climate change.

We are still here in the Senate in an environment in which we are still frequently told that there are scientists that disagree with the fundamental premise of climate change, that manmade carbon emissions are affecting our climate in ways that are adverse for our interests.

How would you characterize the nature of the debate? I am a lawyer, and I could find lawyers who will say that the income tax is unconstitutional. I can find people who will say that they have been taken up in alien spaceships, and they now wear tinfoil over their heads.

In the scientific community, is it just a fringe that is disbelieving this? Or is it a real, live actual scientific debate right down the middle, evenly balanced on both side, or somewhere in between? How would you describe the nature of the debate in the overall scientific community?

Mr. FRUMHOFF. Thank you, Senator. Well, you can certainly find individuals with Ph.Ds. in science who would characterize the science of climate change as highly uncertain. But the broadly cast consensus in the scientific community is otherwise.

Probably the best way to represent that for you, Senator, is by quoting from a letter that was sent to the Senate from 18 scientific societies with relevant expertise in the United States, including the American Geophysical Union, the American Meteorological Society, the American Association for the Advancement of Science and 15 other scientific societies.

"As you consider climate change legislation, we, as leaders of scientific organizations, write to state the consensus scientific view. Observations throughout the world make it clear that climate change is occurring and that rigorous scientific research demonstrates the greenhouse gases emitted by human activities are the primary drivers. These conclusions are based on multiple lines, independent lines of evidence, and contrary assertions are inconsistent with an objective assessment of the vast body of peer-reviewed science."

I could not agree with that statement more.

Senator WHITEHOUSE. OK. Inconsistent with the——

Mr. FRUMHOFF. It was an objective assessment of the vast body of peer-reviewed science.

Senator WHITEHOUSE. Thank you.

Senator BOXER. Thank you. I think that is important. Can we get that letter to put in the record, sir?

Mr. FRUMHOFF. Absolutely.

Senator BOXER. Thank you very much.

[The referenced letter follows:]

October 21, 2009

Dear Senator:

As you consider climate change legislation, we, as leaders of scientific organizations, write to state the consensus scientific view.

Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver. These conclusions are based on multiple independent lines of evidence, and contrary assertions are inconsistent with an objective assessment of the vast body of peer-reviewed science. Moreover, there is strong evidence that ongoing climate change will have broad impacts on society, including the global economy and on the environment. For the United States, climate change impacts include sea level rise for coastal states, greater threats of extreme weather events, and increased risk of regional water scarcity, urban heat waves, western wildfires, and the disturbance of biological systems throughout the country. The severity of climate change impacts is expected to increase substantially in the coming decades.[1]

If we are to avoid the most severe impacts of climate change, emissions of greenhouse gases must be dramatically reduced. In addition, adaptation will be necessary to address those impacts that are already unavoidable. Adaptation efforts include improved infrastructure design, more sustainable management of water and other natural resources, modified agricultural practices, and improved emergency responses to storms, floods, fires and heat waves.

We in the scientific community offer our assistance to inform your deliberations as you seek to address the impacts of climate change.

---

[1] The conclusions in this paragraph reflect the scientific consensus represented by, for example, the Intergovernmental Panel on Climate Change and U.S. Global Change Research Program. Many scientific societies have endorsed these findings in their own statements, including the American Association for the Advancement of Science, American Chemical Society, American Geophysical Union, American Meteorological Society, and American Statistical Association.

American Association for the Advancement of Science
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Alan I. Leshner
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Timothy L. Grove
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May R. Berenbaum
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Sciences

Keith Seitter
Executive Director
American Meteorological Society

Mark Alley
President
American Society of Agronomy

Tuan-hua David Ho
President
American Society of Plant Biologists

Sally C Morton
President
American Statistical Association

Lucinda Johnson
President
Association of Ecosystem Research
Centers

Kent E. Holsinger
President
Botanical Society of America

Kenneth Quesenberry
President
Crop Science Society of America

William Y. Brown
President
Natural Science Collections Alliance

Douglas N. Arnold
President
Society for Industrial and Applied Mathematics

Paul Bertsch
President
Soil Science Society of America

Mary Power
President
Ecological Society of America

Brian D. Kloeppel
President
Organization of Biological Field Stations

John Huelsenbeck
President
Society of Systematic Biologists

Richard A. Anthes
President
University Corporation for Atmospheric Research

Senator WHITEHOUSE. Madam Chair, could I ask unanimous consent to put an additional letter in the record? This one is from the Reinsurance Association of America regarding the way in which they have had to adapt to the effects of climate change in the insurance industry.

Senator BOXER. Without objection.

[The referenced letter follows:]

RAA
REINSURANCE ASSOCIATION OF AMERICA
1301 Pennsylvania Avenue, N.W.
Washington, D.C. 20004

Telephone: (202) 638-3690
Facsimile: (202) 638-0936
http://www.reinsurance.org

October 1, 2009

Senator Barbara Boxer
Chairman, Environment and Public Works Committee
410 Dirksen Senate Office Building
Washington, D.C. 20510-6175

Senator John Kerry
Chairman, Foreign Relations Committee
446 Dirksen Senate Office Building
Washington, D.C. 20510-6225

Dear Senators Boxer and Kerry:

As leaders in the property insurance and reinsurance industries, we applaud your efforts to win bipartisan approval of the Clean Energy Jobs and American Power Act that will combat the adverse impacts of climate change. The success of our companies depends upon the accurate assessment and management of risks to human life, property and the environment. Thus, it is important that Congress properly address the many risks that are attributable to climate change.

Although our companies are not engaged in the policy debate over the best ways to reduce greenhouse gas emissions, we have been actively engaged in the debate over how to assess and reduce the risks of storms, floods and wildfires, all of which are now being exacerbated by climate change. We have reviewed the domestic and natural resources adaptation provisions in your legislation and we believe that they would create a powerful and essential framework for identifying and reducing the risk of climate change for affected communities as well as natural resources.

The bill's provisions, which call for projects, programs and measures to build resilience to predicted impacts of climate change which are essential for the protection of life and property. Provisions that will assure for the protection and restoration of coastal wetlands, floodplains, ocean, and other natural resources will not only provide important benefits for our environment, but by protecting these areas, natural "buffer zones" can be created which will reduce climate-related risk to people and property. Additionally, we support a robust level of funding for the adaptation provisions, as well as provisions assuring that federal and state adaptation plans are consistent with conservation, and environmental laws.

We appreciate your important achievement in advancing climate change legislation and, as the Clean Energy Jobs and American Power Act moves through the legislative process, we look forward to working with you on the bill's domestic and natural resources provisions

Sincerely,

Franklin W. Nutter
President

Senator BOXER. So, our last questioner is Senator Cardin.

The floor is yours.

Senator CARDIN. Well, thank you, Chairman Boxer. I think I started off the first round of questioning this morning——

Senator BOXER. You did.

Senator CARDIN. I think it was this morning.

Senator BOXER. It feels like it has been——

Senator CARDIN. It has been a long day with a lot of witnesses and a lot of good information to help us in our work, and I just think the last exchange between Dr. Frumhoff and Senator Whitehouse was particularly important. We want our actions based on good science, which is likely to happen.

I just think of Maryland, my own State, and in my lifetime, I have seen the impact of sea level rising in Maryland. In my lifetime. And if Secretary Wilson is correct, and we do not take action, and we see a 2.5- to 3.5-foot increase in sea level in the Chesapeake Bay, it is going to have a devastating impact. You do not need a Ph.D. degree to understand what is going to happen. We have already seen significant flooding at the U.S. Naval Academy.

Yes, I understand which is the Ocean State here, Senator Whitehouse. We have this friendly debate——

Senator BOXER. We have an ocean on our side.

[Laugher.]

Senator CARDIN. Right. And you do. It is a beautiful ocean. But you do not have as much coastline as we do. We have 3,000 miles of coastline in Maryland alone.

Senator BOXER. OK, let us just say we have plenty.

[Laughter.]

Senator CARDIN. Right. You have plenty. And you are impacted like we are all impacted on the sea level increase.

Senator BOXER. I just have to remind you of the West Coast every once in a while.

Senator CARDIN. Right. We come out there every once in a while. And we do appreciate, Chairman Boxer, you recognition of the adaptation problems of the coastal areas and the allocations that you have made.

I guess my point is that I have been to the developed areas along our coast, and I know the vulnerability. I have been to the reserves, Blackwater Reserve, and look at the acreage that we have lost because of sea level and erosion. And know that if we do not take action, and we lose these assets, it is going to cause irreversible damage to my State of Maryland, to the Chesapeake Bay and to your country.

So, we have got to be judged by good science. But we do know the impact of what is happening here, and we have got to take action, and the good part about this bill is that this bill takes action to deal with the underlying problem of global climate change by setting targets for us to meet.

But then you also deal with the damage that has been caused as a result of global climate change, right here in America and along or coastal ways. We thank you for that.

Secretary Wilson, I want to get you engaged a little bit in some of the green infrastructure that we are doing in Maryland, how important that is, some of our programs and dealing with the way that we deal with runoff, and how important is green infrastructure in trying to develop the right strategy to counter the damages that are being done as a result of global climate change.

Ms. WILSON. The green infrastructure is, it ranks right up there at the top of adaptation strategies that a State, a coastal State, can take to deal with the effects of sea level rise.

By way of example, with the State of Maryland's Climate Action Plan and the adaptation strategy, we have got some strategy implementation underway already, and one of those strategies is to ensure that we put in place living shorelines instead of hard bulkheads wherever possible. They are better able to absorb sea level rise, and they also greatly improve habitat.

So, for example, with the green infrastructure funded through the ARA funding process, we have jump started our living shorelines projects along the shoreline of the Chesapeake Bay. It is a critical part of how we can adapt.

And I think that is the point of the testimony here today is that there are things we need to be doing right now to get adaptation underway. The 2 to 3.4 feet of sea level rise you mentioned, that is in a lowered emissions reduction scenario. So, we know we have got these impacts coming, and this act puts in place a procedure and a process and a way for the country to get adaptation on the ground now, including the green infrastructure projects.

Senator CARDIN. I think that is a very valuable point. The point is that, if we are successful in dealing with global climate change, if not only the United States acts but we act at Copenhagen, and there is an international commitment, and we in fact meet our international standards and reduce our warming, we still have to deal with the consequences of global climate change. And this legislation provides the wherewithal by investing in green infrastructure, by dealing with remedial programs, engaging the States. It is not all the Federal Government. We need the help our States. We need the work in the private sector. It is a team effort.

I just thank you all for starting. The States, many States, not just Maryland, many States, Madam Chairman have really moved forward aggressively on this issue in so many different ways, giving us, I think, the blueprint for a national program where America can truly be an international leader on preserving our environment for future generations.

And thank you all very much.

Senator BOXER. So, Senator Cardin, I checked it. California has 1,340 miles of coastline.

Senator CARDIN. Well, I think the Chesapeake Bay, somebody can correct me, I think the Chesapeake Bay has 3,000 miles.

Ms. WILSON. Over 3,000.

Senator BOXER. OK, well that is because you go this way, and this way——

Senator CARDIN. Right. We have a flow a lot. Look, I really think you do deserve one-third the money that we——

Senator BOXER. Whoa. OK. You mean, never mind the 40 million people. OK, I got it.

[Laughter.]

Senator BOXER. Let me say how much I appreciate this panel. Terrific, all of you, just terrific. You are going to get some questions from colleagues, and we are asking that you really turn them around in 24 hours. I know that is difficult.

Mr. Sims, I had a question, and I did not even want to bother you with it. I tried to look it up. Who are the members of the Western Business Roundtable? They are not in, can I just look them up in the——

Mr. SIMS. I will send them to you.

Senator BOXER. OK, because they are not in the Web site.

Mr. SIMS. They are not on the Web site.

Senator BOXER. So we will officially ask you for that.

Mr. SIMS. We will send you our membership list.

Senator BOXER. I appreciate that very much.

Mr. SIMS. Can I ask just one favor in return?

Senator BOXER. Yes.

Mr. SIMS. I did not get a chance to talk about this, but I want to enter this in the record if that is OK?

Senator BOXER. Yes.

Mr. SIMS. Madam Chairman, you have a reading list that is lengthier than any of us, so I hesitate to ask you to really take a look at something. But I think you should look at this. It is very short. It is an analysis done by one of my members who is an engineer and a very smart one. And what he does is, he simply goes through and he does cast some very serious doubt, which I think you should pay attention to, the contention that some of these bills, it was not specific to this one, would create all of these millions of green jobs. I would recommend that you take a look at it.

Senator BOXER. I will. And I will also put in the record, at the same time, the recent studies that have just come out by U.C. Berkeley and University of Illinois, and also the Pew Charitable Trust that shows, and the Center for American Progress, there are just many of them. But we will put them all in together, and of course, we are happy to look at you. Who is this person? What is his name?

Mr. SIMS. Kimball Rasmussen, who is the CEO of Deseret Power.

[The referenced information follows:]

the CleanEnergy Economy

Repowering Jobs, Businesses and Investments Across America

THE PEW CHARITABLE TRUSTS

JUNE 2009

The Pew Charitable Trusts applies the power of knowledge to solve today's most challenging problems. Our Pew Center on the States identifies and advances effective policy approaches to critical issues facing states, and our Pew Environment Group promotes practical, meaningful solutions to some of the world's most pressing environmental problems.

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Advisory Panel: Marilyn Brown, professor, School of Public Policy, Georgia Institute of Technology; Doug Cameron, managing director and chief science advisor, Piper Jaffray; Joe Cortright, vice president and principal, Impresa; Jeff Finkle, CEcD, president and CEO, International Economic Development Council; Tim Woodward, managing director, Nth Power; and Joel S. Yudken, PhD, principal, High Road Strategies, LLC.

External Reviewers: Mark Z. Jacobson, professor of Civil and Environmental Engineering and director, Atmosphere/Energy Program, Stanford University; and Joe Fargione, Lead Scientist, North America Region, The Nature Conservancy.

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For additional information on The Pew Charitable Trusts, please visit www.pewtrusts.org.

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THE PEW CHARITABLE TRUSTS

June 2009

Dear Reader:

Public- and private-sector leaders are working hard to create a brighter economic future for our country, one in which new industries create well-paying, enduring jobs for Americans and spark growth from coast to coast.

The clean energy economy, still in its infancy, is emerging as a vital component of America's new economic landscape. That's the finding of *The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America*, a groundbreaking analysis by The Pew Charitable Trusts that sheds light on an increasingly important part of the nation's economic recovery.

Pew counted actual jobs, companies and investments in every state and the District of Columbia aimed at developing clean, renewable sources of energy, increasing energy efficiency, reducing greenhouse gas emissions that cause global warming, and conserving water and other natural resources. We found that jobs and businesses in the emerging clean energy economy have grown at a faster rate than U.S. jobs overall. And they are poised for even greater growth, driven by increasing consumer demand, venture capital infusions by investors eager to capitalize on new market opportunities, and policy reforms by federal and state lawmakers seeking to spur America's fiscal recovery, reduce our dependence on foreign oil and protect the environment.

This report reflects the intersection of two of Pew's lines of work. The Pew Center on the States identifies and advances effective approaches to improve states' fiscal health and economic competitiveness, and the Pew Environment Group promotes practical, meaningful policy solutions to some of the world's most pressing environmental problems.

Across the country, state lawmakers also are pursuing the dual goals of economic growth and environmental sustainability. A growing number of states are implementing policies to capitalize on the clean energy economy, from renewable portfolio and energy efficiency standards to financial incentives for public- and private-sector innovation and investment.

At the federal level, the American Recovery and Reinvestment Act provides tens of billions of dollars to bolster those efforts. But to realize the clean energy economy's full potential, federal leaders must do more. The nation needs a comprehensive, economy-wide energy plan, a market-based system that will significantly reduce emissions that cause global warming and derive more of America's energy supply from clean, renewable sources. Strong federal policies will accelerate the growth of this economic sector by generating jobs and businesses that develop clean energy and increase energy efficiency.

As federal and state lawmakers consider these and other critical reforms, Pew will conduct follow-up research to determine which policy approaches most effectively help America achieve the double bottom line of economic growth and environmental sustainability. We hope this report will inform and guide our nation's leaders as they seek to expand our emerging clean energy economy.

Sincerely,

Susan Urahn	Joshua Reichert
Managing Director	Managing Director
The Pew Center on the States	The Pew Environment Group

Executive Summary

America's clean energy economy is dawning as a critical component of the nation's future.

Research by The Pew Charitable Trusts shows that despite a lack of sustained policy attention and investment, the emerging clean energy economy has grown considerably—extending to all 50 states, engaging a wide variety of workers and generating new industries. Between 1998 and 2007, its jobs grew at a faster rate than overall jobs. Like all other sectors, the clean energy economy has been hit by the recession, but investments in clean technology have fared far better in the past year than venture capital overall. Looking forward, the clean energy economy has tremendous potential for growth, as investments continue to flow from both the government and private sector and federal and state policy makers increasingly push for reforms that will both spur economic renewal and sustain the environment.

By 2007, more than 68,200 businesses across all 50 states and the District of Columbia accounted for about 770,000 jobs that achieve the double bottom line of economic growth and environmental sustainability (Exhibit 1).

In today's tough financial climate, when millions of jobs have been lost, those numbers may sound modest. Three quarters of a million jobs represent half a percent of all jobs in the United States today. But Pew's research shows that between 1998 and 2007, clean energy economy jobs—a mix of white- and blue-collar positions, from scientists and engineers to electricians, machinists and teachers—grew by 9.1 percent, while total jobs grew by only 3.7 percent. And although we expect job growth in the clean energy economy to have declined in 2008, experts predict the drop in this sector will be less severe than the drop in U.S. jobs overall.

Pew's research indicates a strong start for a new economy still very much in its infancy. To put our clean energy economy numbers in perspective, consider the following. Biotechnology, which has developed applications for agriculture, consumer products, the environment and health care and has been the focus of significant public policy and government and private investment, employed fewer than 200,000 workers, or about a tenth of a percent of total U.S. jobs in 2007, according to a 2008 Ernst & Young report. And the well-established traditional energy sector—including utilities, coal mining and oil and gas extraction, industries that have received significant government investment—comprised about 1.27 million workers in 2007, or about 1 percent of total employment.

Growing attention and financial support from both the private and public sectors indicate that the clean energy economy is poised to expand significantly. Signaling interest in new market opportunities, venture capital investment in clean technology crossed the $1 billion threshold in 2005 and continued to grow substantially, totaling about $12.6 billion during the past three years. Although they have dropped significantly in recent months because of the recession, investments in clean technology are actually faring better than other industries: They were down 48 percent in the first three months of 2009 compared with a year earlier, while total venture capital across all sectors was down 61 percent for the same period. "It's important not to miss the forest for the trees," Nicholas Parker, executive chairman of the Cleantech Group, said in January 2009. "In 2008, there was a quantum leap in talent, resources and institutional appetite for clean technologies. Now, more than ever, clean technologies represent the biggest opportunities for job and wealth creation."

Between 2006 and 2008, 40 states and the District of Columbia attracted venture capital investments in technologies and industries aimed at economic growth and environmental sustainability. And all states will receive a major infusion of federal funds through the recently enacted American Recovery and Reinvestment Act (ARRA), which allocates nearly $85 billion in direct spending and tax incentives for energy- and transportation-related programs.

Every State Has a Piece of the Clean Energy Economy

With traditional manufacturing jobs declining during the past decade, states have been working aggressively to develop new industries and create jobs that will endure—and remain within U.S. borders. They also have been working to address the public's concerns about high energy prices, national security and our dependence on foreign oil, and global warming—all with an understanding that America is on its way to being a carbon-constrained country. "While our economic engine has for years been powered by relatively inexpensive energy, there is evidence that this era is coming to a close," a National Governors Association report noted in 2007. "Meanwhile, we are increasingly aware of the serious impacts of global climate change—and how America's consumption of fossil fuels is contributing to a warming Earth."

Pew's analysis shows that every state has a piece of America's clean energy economy. Texas, for instance, generates more electricity from wind than any other state, had more than 55,000 clean energy economy jobs in 2007, and attracted more than $716 million in venture capital funds for clean technology between 2006 and 2008. Tennessee has succeeded in cultivating jobs in recycling, waste treatment and water management, among other conservation industries; jobs in Tennessee's clean energy economy grew by more than 18 percent between 1998 and 2007, compared with 2.5 percent growth in all jobs in the state. Colorado has raised the amount of power electricity providers must supply from renewable energy sources to stimulate job growth in solar and wind power and other forms of clean energy generation. Ohio ranked among the top five states with the most jobs in clean energy, energy efficiency and environmentally friendly production in 2007. Idaho, Kansas, Mississippi and South Dakota are among more than a dozen states where the number of jobs in the clean energy economy in 2007 was modest, but the average annual growth rate of those jobs was among the highest in the country. All told, in 38 states and the District of Columbia, job growth in the clean energy economy outperformed total jobs growth between 1998 and 2007. In a number of states, job gains in the clean energy economy have helped lessen total job losses.

Defining the Clean Energy Economy

Pew partnered with Collaborative Economics, Inc., a public policy research firm based in California, on the research. While organizations on both sides of the political spectrum have weighed in with forecasts and economic modeling to estimate the size of the clean energy economy, Pew's analysis is the first of its kind to count actual jobs, businesses and investments for each of the 50 states and the District of Columbia. Our numbers are conservative and may be lower than some other reports for three reasons: First, we developed a stringent definition of the clean energy economy; second, we used a new, labor-intensive methodology that counted only companies that we could verify online as being actively engaged in the clean energy economy; and third, we counted businesses and jobs supplying products and services generated by the clean energy economy, not the companies using these products and services to make themselves "greener" (i.e., we counted only companies and jobs on the supply side, not the demand side, of the clean energy economy).

Policy makers, business leaders and the public need credible, reliable data to ground their policy deliberations and choices, and to understand where emerging economic opportunities lie. They also need a clear, concrete and common definition of what constitutes the clean energy economy so they can track jobs and businesses and gauge the effectiveness of public policy choices and investments.

Based on significant research and input from experts in the field, including the advisory panel that helped guide this study, Pew developed the following definition:

A clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources.

The clean energy economy cuts across five categories: (1) Clean Energy; (2) Energy Efficiency; (3) Environmentally Friendly Production; (4) Conservation and Pollution Mitigation; and (5) Training and Support.

While specific jobs and businesses will change in the coming decades, the five categories of the clean energy economy will not—providing a clear, practical and consistent framework for federal, state and local policy makers and the private sector to track investments, job and business creation, and growth over time.

Jobs of Today, and Jobs of Tomorrow

Pew's framework takes into account that technology, scientific research, market forces and public policy will continue to drive innovation and competition, so the largest segments of today's clean energy economy may not be its driving forces tomorrow.

Our data show that 65 percent of today's clean energy economy jobs are in the category of Conservation and Pollution Mitigation—a sector that reflects the growing recognition among the public, policy makers and business leaders of the need to recycle waste, conserve water and mitigate emissions of greenhouse gases and other pollutants. But three other categories—Clean Energy, Energy Efficiency and Environmentally Friendly Production—are growing at a far faster clip. And about 80 percent of venture capital investments in 2008 were in the sectors of Clean Energy and Energy Efficiency: businesses and jobs working to develop clean, renewable energy sources such as wind and solar and products and services that reduce our overall energy consumption—all of which will help meet the demands of a carbon-constrained economy.

The flow of venture capital indicates which sectors are most attractive to investors and have the greatest growth potential. The number of jobs and businesses in Clean Energy and Energy Efficiency will grow over time—and as the country increases the amount of power it draws from renewable sources, we will generate less waste, reduce our reliance on foreign oil and produce fewer carbon emissions that cause global warming. That does not mean that jobs in the Conservation and Pollution Mitigation category will disappear. As other countries seek to follow America's lead, they increasingly will need help managing their finite natural resources and addressing the adverse effects of their use of fossil-fuel energy sources—creating a new market for our products, technology and know-how.

Public Policy's Role in Driving the Clean Energy Economy

Public policy is another important indicator of the future of the clean energy economy.

Policies intended to advance the clean energy economy—from comprehensive energy plans, renewable energy standards and energy efficiency measures to the development of alternative fuels, job retraining and waste reduction efforts—have been adopted or are being actively considered by both the federal government and states. It is too early to tell to what degree these efforts will succeed in stimulating U.S. job growth, strengthening America's competitiveness, curbing pollution and conserving resources. But Pew's analysis indicates such policies have great potential because they create significant incentives for both the private and public sectors to develop new technologies, infrastructure and processes for clean energy, efficiency and conservation. Now that we have baseline data in hand, Pew will conduct follow-up research to assess which approaches are particularly effective in generating jobs, businesses and investments in the clean energy economy.

State policies. Governors and legislators across the country are seeking to get to the double bottom line of economic growth and environmental sustainability by adopting policies to advance the clean energy economy.

- *Financial incentives.* Forty-six states offer some form of tax incentive to encourage corporations and residents to use renewable energy or adopt energy efficiency systems and equipment. Thirty-three states provide residential, commercial and industrial loan financing for the purchase of renewable energy or energy efficiency systems or equipment. And 22 states and the District of Columbia offer rebate programs to promote the installation of solar water heating or solar panels for electricity generation.
- *Renewable portfolio standards.* Twenty-nine states and the District of Columbia have adopted renewable portfolio standards, which require electricity providers to supply a minimum amount of power from renewable energy sources.
- *Energy efficiency standards.* Nineteen states have established energy efficiency standards for energy generation, transmission and use.

- *Regional clean energy initiatives.* Twenty-three states are participating in three major regional initiatives seeking to increase renewable energy generation and reduce carbon pollution from power plants that causes global warming.
- *Vehicle emissions standards.* Fourteen states and the District of Columbia have adopted (and three more states are poised to adopt) California's vehicle emissions standards, which allow states the right to require automakers to reduce carbon emissions from new cars and light trucks more aggressively than federal standards mandate. On May 19, 2009, President Barack Obama established national limits on vehicle emissions by adopting fuel efficiency standards that match California's.

Federal policies. The federal government also has played a critical role, adopting policies and making investments that have spurred economic growth and environmental protection from coast to coast. Laws enacted in the 1960s and 1970s helped develop the recycling, waste reduction and waste management industries. The EPA's Energy Star and Water Sense certification and labeling initiatives long have helped consumers choose and use products that conserve energy and water. And for almost two decades, the U.S. Department of Commerce has helped manufacturers improve efficiency, reduce waste and develop clean technologies and products.

In the last three years, federal policy makers have taken major steps to drive the clean energy economy forward. President Obama's recent efforts to enact stronger fuel efficiency standards built on earlier legislation. In 2007, President George W. Bush signed into law the first congressionally mandated increase in fuel efficiency standards for cars and light trucks in more than 30 years. The Energy Independence and Security Act of 2007 is projected to save consumers $25 billion at the gas pump, save 1.1 million barrels of oil a day and reduce greenhouse gas emissions.

Enacted in February 2009, ARRA—the federal stimulus bill—includes an array of provisions to spur clean energy generation and energy efficiency businesses, jobs and investments. Among the almost $85 billion the package allocates to energy- and transportation-related spending, about $21 billion is dedicated to extending tax incentives for wind, solar and other renewable energy manufacturers. ARRA also provides more than $30 billion for direct spending on clean energy programs, including $11 billion to modernize the nation's electricity grid; $2 billion for advanced battery technology; more than $6 billion for state and local efforts to achieve energy efficiency; $5 billion for weatherization of low-income homes; $500 million for job training to help workers participate in the clean energy economy; and $300 million to purchase thousands of new, fuel-efficient vehicles for the federal fleet from American auto companies.

Moving forward. Given America's need to create enduring jobs and industries while conserving natural resources and reducing carbon emissions, federal leaders are deliberating additional measures to spur the clean energy economy.

President Obama has signaled his support for a federal clean energy plan to reduce greenhouse gas emissions by at least 80 percent by 2050, and a national renewable portfolio standard that would require that 25 percent of the nation's energy supply be derived from renewable sources by 2025. At this writing, the U.S. House of Representatives is considering the American Clean Energy and Security Act, a market-based proposal that would limit overall greenhouse gas emissions and distribute tradable federal allowances for each ton of pollution emitted. The program would apply to electric utilities, oil companies and other entities that produce more than 25,000 tons of carbon dioxide each year. The bill would increase significantly the amount of energy derived from low- or zero-carbon sources, including renewables—meaning that businesses and jobs would be generated to develop clean energy sources to meet the demand.

EXHIBIT 1
THE U.S. CLEAN ENERGY ECONOMY BY THE NUMBERS

By 2007, 68,203 businesses in the United States had generated more than 770,000 jobs in the clean energy economy. And between 2006 and 2008, about $12.6 billion of venture capital investments was directed toward clean technology businesses in 40 states and the District of Columbia. The U.S. clean energy economy is an emerging source of jobs that achieve the double bottom line of economic growth and environmental sustainability. Every state has a piece of America's clean energy economy.

	CLEAN BUSINESSES 2007	CLEAN JOBS 2007	CLEAN JOB GROWTH 1998-2007	OVERALL JOB GROWTH 1998-2007	VENTURE CAPITAL 2006-2008 (thousands)
Alabama	799	7,849	2.2%	1.6%	$0
Alaska	350	2,140	9.4	15.7	0
Arizona	1,123	11,578	21.3	16.2	31,106
Arkansas	448	4,597	7.8	3.5	22,845
California	10,209	125,390	7.7	6.7	6,580,427
Colorado	1,778	17,008	18.2	8.2	622,401
Connecticut	857	10,147	7.0	-2.7	30,050
Delaware	211	2,368	-2.3	-8.9	3,342
District of Columbia	280	5,325	18.8	-7.1	89,877
Florida	3,831	31,122	7.9	22.4	116,980
Georgia	1,827	16,222	10.8	15.7	179,686
Hawaii	356	2,732	43.6	7.3	12,304
Idaho	428	4,517	126.1	13.8	27,890
Illinois	2,176	28,395	-2.5	-2.5	108,519
Indiana	1,268	17,298	17.9	-1.0	26,000
Iowa	729	7,702	26.1	3.6	149,237
Kansas	591	8,017	51.0	-0.3	13,275
Kentucky	778	9,308	10.0	3.6	0
Louisiana	995	10,641	19.5	3.0	0
Maine	725	6,000	22.7	3.3	0
Maryland	1,145	12,908	-2.4	1.3	323,996
Massachusetts	1,912	26,678	4.3	-4.4	1,278,462
Michigan	1,932	22,674	10.7	-3.6	55,099
Minnesota	1,206	19,994	11.9	1.9	49,938
Mississippi	454	3,200	24.8	3.6	30,384
Missouri	1,062	11,714	5.4	2.1	24,480

	CLEAN BUSINESSES 2007	CLEAN JOBS 2007	CLEAN JOB GROWTH 1998-2007	OVERALL JOB GROWTH 1998-2007	VENTURE CAPITAL 2006-2008 (thousands)
Montana	408	2,155	0.2%	12.7%	$0
Nebraska	368	5,292	108.6	-4.9	0
Nevada	511	3,641	28.8	26.5	19,804
New Hampshire	465	4,029	2.0	6.8	66,917
New Jersey	2,031	25,397	-9.6	-2.7	282,568
New Mexico	577	4,815	50.1	1.9	147,913
New York	3,323	34,363	-1.9	-2.6	209,590
North Carolina	1,783	16,997	15.3	6.4	82,571
North Dakota	137	2,112	30.9	9.4	0
Ohio	2,513	35,267	7.3	-2.2	74,224
Oklahoma	693	5,465	6.8	2.4	5,192
Oregon	1,613	19,340	50.7	7.5	70,002
Pennsylvania	2,934	38,763	-6.2	-3.1	232,897
Rhode Island	237	2,328	0.7	0.6	22,845
South Carolina	884	11,255	36.2	2.2	0
South Dakota	169	1,636	93.4	4.9	0
Tennessee	1,090	15,507	18.2	2.5	16,329
Texas	4,802	55,646	15.5	6.7	716,894
Utah	579	5,199	-12.4	10.8	26,957
Vermont	311	2,161	15.3	7.4	53,747
Virginia	1,446	16,907	6.0	6.6	70,828
Washington	2,008	17,013	0.5	1.3	635,109
West Virginia	332	3,065	-4.1	0.7	5,741
Wisconsin	1,294	15,089	-5.2	3.4	46,743
Wyoming	225	1,419	56.4	14.0	6,942
U.S. Total	68,203	770,385	9.1	3.7	12,570,110

NOTE: Venture capital values are adjusted for inflation and reported in 2008 dollars. See appendices for the complete data sets.
SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database and data from the Cleantech Group™ LLC; analysis by the Pew Center on the States and Collaborative Economics

The Clean Energy Economy: A Definition and Framework

Manufacturing plants of old—the destination for thousands of workers and lifeblood of whole communities—have been on the decline for years. In 2007, there were just under 14 million manufacturing jobs, but the industry has shrunk every year over the last decade. Between 1998 and 2007, manufacturing jobs declined by nearly 21 percent, an average of 2.6 percent annually.[1] Many companies have shut down as consumers turned to newer products and innovations or as more profitable business models emerged in other states or countries. This long, steady decline accelerated during the past year as the recession hit, leaving workers in need of jobs—and states in need of new industries to serve as their economic engines.[2] Today, a growing number of states are looking to identify and cultivate new industries and areas of economic growth to help them better compete in the 21st century global marketplace. The public and policy makers alike want more than a short-term fix for the immediate fiscal crisis. They want new lines of business that will create jobs, generate revenues for many years to come and help America re-emerge as a technological leader.

With three quarters of Americans describing climate change as a serious problem,[3] states also have been working to address the public's concerns about our shrinking supply of traditional energy sources, the nation's overreliance on foreign oil and global warming pollution. "While our economic engine has for years been powered by relatively inexpensive energy, there is evidence that this era is coming to a close," a National Governors Association report noted in 2007.[4] "Meanwhile, we are increasingly aware of the serious impacts of global climate change—and how America's consumption of fossil fuels is contributing to a warming Earth." Nearly half the states have joined regional initiatives aimed at reducing carbon dioxide emissions from power plants and increasing clean energy generation. Twenty-nine states and the District of Columbia have adopted renewable portfolio standards, which require utilities to generate a certain percentage of their power—ranging from 10 percent to 25 percent—from renewable energy sources by a target date.[5] And 19 states have established standards for energy efficiency.[6]

Driven by fiscal interests and concerns about energy and climate change, a growing number of public- and private-sector leaders are seeking to expand their share of the clean energy economy: jobs, businesses and investments that achieve a double bottom line—economic growth and environmental sustainability. This approach is not new; in the late 1990s businesses and policy makers began to recognize that consumer demand for clean products, supplies and activities represented a significant market opportunity. But the promise and priority of the clean energy economy have risen sharply in response to the current economic recession and our increasing dependence on fossil fuels.

Through the American Recovery and Reinvestment Act (ARRA), which was signed into law in February 2009, President Barack Obama and Congress have pumped substantial federal funds into cultivating the clean energy economy—nearly $85 billion in direct spending and tax credits for energy- and transportation-related programs.[7] But even before ARRA, a growing number of states, from Tennessee and Texas to Colorado, Michigan and Ohio, were beginning to capitalize on the clean energy economy's double bottom line of economic growth and environmental sustainability.

Michigan has lost jobs since 2000 as the Detroit-based auto manufacturers have faltered; by March 2009, the state's unemployment rate was the highest in the country, at 12.6 percent—an increase of 5 percentage points in just one year.[8] Today, the clean energy economy is a central component of Michigan's recovery strategy. Part of Governor Jennifer Granholm's "No Worker Left Behind" program aims to create clean energy jobs for Michigan residents, and she tasked Skip Pruss, director of the state's Department of Energy, Labor and Economic Growth, with making that goal a reality.[9] "Every state wants to be a leader in the area for clean energy generation and energy efficiency," said Pruss. "There's keen competition; it's very dynamic. But there's enough opportunity for everyone to really improve and diversify their economies."[10]

Given the burgeoning interest in the clean energy economy, policy makers, business leaders and the public need credible, reliable data to ground their policy deliberations and choices, and to understand where growth is heading. And both government and the private sector need a clear and concrete definition of this market so they can track jobs, businesses and investments aimed at both economic growth and environmental sustainability and gauge the effectiveness of public policy choices to support such efforts.

Pew sought first to clearly define the clean energy economy and then count the actual number of jobs, businesses and investments in it. Pew's accounting of the clean energy economy was developed from the ground up. Our analysis is conservative relative to other studies because we count actual clean energy economy businesses and jobs rather than entire occupations (such as all jobs in mass transit, or all electricians).[11] For example, our report counts the workers who manufacture hybrid cars and buses, technicians who construct wind turbines, electricians who install solar panels on homes and engineers who research fuel cell technology, but it does not include all auto manufacturers, electricians, technicians and engineers. In addition, we focus exclusively on producers and suppliers in the clean energy economy. We do not count jobs that use these products and services—for example, jobs within utilities responsible for purchasing energy monitoring equipment or the mass transit operations that buy hybrid buses—because data limitations prevented the disaggregation of specific jobs within these types of companies.

Although our numbers are conservative, our report provides the most precise depiction to date of the clean energy economy in the United States.[12]

The Clean Energy Economy, Defined

Based on significant research and input from experts in the field, including the advisory panel convened to help guide this study, Pew has developed the following definition:

A clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources.

The clean energy economy comprises five categories: (1) Clean Energy; (2) Energy Efficiency; (3) Environmentally Friendly Production; (4) Conservation and Pollution Mitigation; and (5) Training and Support. Pew's researchers organized these five categories from 16 economic sectors (see Appendix A for a complete list).

This framework (Exhibit 2) was designed to describe what the clean energy economy looks like today while leaving room for inevitable future changes. Technology, scientific research, market forces and public policy will continue to drive innovation and competition. A company that supplies natural gas engines for buses, for instance, may supply a fundamentally different type of engine a decade from now. But while specific jobs and businesses will change, the five categories that make up the clean energy economy will not. Our framework provides a clear, practical and consistent tool for federal, state and local policy makers and the private sector to track investments, job and business creation, and growth over time.

EXHIBIT 2

THE CLEAN ENERGY ECONOMY—A DEFINITION

The clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources.

The clean energy economy comprises five categories:

CLEAN ENERGY	ENERGY EFFICIENCY	ENVIRONMENTALLY FRIENDLY PRODUCTION	CONSERVATION AND POLLUTION MITIGATION
Building sustainable energy for the future	Reducing and managing our energy demand	Improving our products and processes	Recycling and remediating waste
TRAINING AND SUPPORT Helping develop our clean energy economy			

Although specific jobs and businesses will change over time, the categories themselves will not—providing a clear, practical and consistent framework for federal, state and local policy makers and the private sector to track investments, job and business creation, and growth over time.

SOURCE: Pew Charitable Trusts, 2009.

The Five Categories of the Clean Energy Economy

Clean Energy. These are jobs, businesses and investments that produce, transmit and store clean, renewable power from solar, wind, low-impact hydro, hydrogen fuel cells, marine and tidal, geothermal[13] and small-scale biopower[14] energy sources.

This category's jobs, businesses and investments meet a stringent set of requirements. Clean energy must have a positive net energy yield, reduce greenhouse gas emissions compared with other sources of energy, and be produced and distributed in a sustainable and safe manner. Nuclear power is not included in this category because of significant, ongoing questions about how and where to safely store its waste; a system to safely dispose of nuclear waste has not been implemented anywhere in the world (see Appendix F).[15] Additionally, we do not include the jobs and businesses associated with the production and distribution of liquid biofuels such as corn-based ethanol in the Clean Energy category because they do not meet its requirements.[16] As explained in more detail below, these jobs and businesses are included in the Environmentally Friendly Production category instead.

Examples of jobs: Electricians, electrical engineers and plumbers help install new energy systems, while plant operators ensure that renewable sources such as wind and solar are being converted to electricity. Mechanics rebuild ailing energy infrastructure by installing sensors and controls that monitor and distribute clean energy more effectively (i.e., making the grid smarter). Researchers and technicians perfect and implement battery technologies that improve how we store and distribute clean energy.

Energy Efficiency. These are jobs and businesses that help Americans reduce the amount of energy we use, whether to run a manufacturing plant or heat and cool an office building or home. Expanding the use of clean, renewable energy sources will take time, so improved energy efficiency helps reduce our use of fossil fuels in the short term and use less energy—from both fossil fuels and renewable sources—in the long term.

Examples of jobs: Engineers develop energy-efficient lighting, meters, software programs and other products that help curb and monitor energy usage, while electricians and others install them in homes, businesses and government buildings.

Environmentally Friendly Production. These are jobs, businesses and investments that seek to mitigate the harmful environmental impacts of existing products and develop and supply alternatives that require less energy and emit fewer greenhouse gases. Environmentally friendly production comprises six areas: transportation, manufacturing, construction, agriculture, energy production and materials.

Examples of jobs:

- Transportation includes jobs that produce hybrid diesel buses, traffic monitoring software and liquid biofuels. This includes only facilities where feedstocks are distilled into biofuels and centers that distribute them—i.e., the biofuels infrastructure; it does not include agricultural jobs that supply feedstocks to produce liquid biofuels.[17] We include biofuels infrastructure because the commercialization of second-generation biofuels from the cellulose in plants and waste holds the potential to produce an energy source that does not divert substantial amounts of land from growing food or damage the environment.

- Manufacturing includes chemists who produce environmentally sound packaging, equipment and surface cleaning products that are less caustic than traditional products.
- Construction includes workers who produce and install green building material such as alternative cement and manufactured wood products made from scraps, and consultants who provide green building design and construction services.
- Agriculture includes plumbers and technicians who install smart irrigation systems, as well as chemists who design alternative pest controls and consultants who provide agricultural sustainability planning.
- Energy production includes jobs that design and apply cleaner technologies to coal such as gasification, pyrolysis, and carbon capture and sequestration (CCS). Coal provides nearly 50 percent of America's electricity,[18] but it also produces about 80 percent of the electricity sector's carbon dioxide emissions.[19] CCS technology is still under development, but our definition includes efforts that seek to reduce the adverse impacts of coal in the near future while the country works to develop clean, renewable energy sources.[20]
- Materials includes product designers and engineers who develop biodegradable products and chemical engineers who research new chemical catalysts to break down wastes and reduce toxins naturally.

Conservation and Pollution Mitigation. These are jobs, businesses and investments that enable the United States to manage water and other finite natural resources more effectively and to mitigate emissions of greenhouse gases and other pollutants that result from the continued use of fossil fuels.[21] Also included are efforts to recycle materials used in production processes, which can save energy. For example, recovering aluminum from scrap (from manufacturing plants as well as from aluminum products) to refine and produce aluminum a second time uses less than 5 percent of the energy required to produce primary aluminum.[22]

Examples of jobs: Trained workers safely remediate hazardous materials from industrial sites; scientists and technicians develop, install and supply products to capture and treat noxious greenhouse gases and pollutants; machinists and system operators treat water and waste; and environmental consultants help companies and governments improve emissions monitoring, water conservation and recycling.

Training and Support. These are jobs, businesses and investments that provide specialized services to the other four categories of the clean energy economy.

Examples of jobs: Financial analysts and consultants specialize in clean tech investments, lawyers and paralegals provide legal services, researchers and engineers develop new energy generation technologies, and vocational teachers train new workers for the clean energy economy.

Methodology

This report counts jobs, companies, patent registrations and venture capital investments that are part of the clean energy economy, as Pew defines it, across all 50 states and the District of Columbia. Because a perfect data set with which to count these jobs and businesses does not exist, and obtaining an accurate count of this emerging economic activity is difficult, Pew used data that provide detailed information on individual companies.

As a first step, Pew's researchers identified companies receiving clean technology venture capital. Next, we used the National Establishment Time Series (NETS) database—a time series database of U.S. public and private establishments based on data from Dun & Bradstreet—to identify similar and related companies. This approach enabled us to capture the different sets of activities that result in products and services produced and supplied by the clean energy economy, creating the most comprehensive and accurate count of jobs yet available. For the purposes of this analysis, we studied jobs and businesses between 1998 and 2007.

As noted earlier, there is no straightforward classification of jobs and businesses in the clean energy economy. To compensate for this, Collaborative Economics Inc., Pew's research partner, created a new database to track businesses in the clean energy economy and, in combination with NETS, identified companies in the clean energy economy across the nation. The research team designed a Web search engine to find company Web sites and to verify that these businesses were still actively engaged in the clean energy economy, based on our definition. Then a team of analysts manually checked the validity of the 50-state data. Given the methodology and standards employed, our count of businesses and jobs is probably conservative.

Venture capital investment data were provided by the Cleantech Group, which tracked investments by industry category. We obtained new patent registrations, based on U.S. Patent and Trade Office records, with the help of intellectual property experts at 1790 Analytics. Both patent and venture capital data were collected for the period from 1999 to 2008.

See Appendix B for a more detailed description of our methodology.

The Clean Energy Economy: National Numbers

Businesses and Jobs

Driven by growing consumer demand, public policy decisions and public- and private-sector investments, America's clean energy economy today comprises more than three quarters of a million jobs. By 2007, the last year for which data are available, 68,203 businesses across all 50 states and the District of Columbia had created 770,385 jobs in the clean energy economy. While this represents half a percent of all jobs in the United States, Pew's research shows that between 1998 and 2007, jobs in the clean energy economy grew by 9.1 percent, while total jobs grew by just 3.7 percent. And although we expect the national recession to have caused a decline in jobs that are part of the clean energy economy in 2008, experts predict it will be less severe than the drop in overall U.S. jobs.[23]

To put these numbers in perspective, consider the following. Biotechnology, which has developed applications for agriculture, consumer products, the environment and health care and has been the focus of significant public policy[24] and private investment,[25] employed fewer than 200,000 workers, or about a tenth of a percent of total U.S. jobs in 2007.[26] And the well-established traditional energy sector—including utilities, coal mining and oil and gas extraction, industries that have received significant government investment—comprised about 1.27 million workers in 2007, or about 1 percent of total employment.[27]

Workers from all walks of life and diverse professional backgrounds are the engine of the clean energy economy. Plumbers, machinists, scientists, engineers, bankers and marketing consultants all contribute to it—with annual incomes ranging from approximately $21,000 to $111,000.[28] "The range of jobs will be from entry level to high level and they will all evolve as the industry evolves," Kathy Krepcio, executive director of the John J. Heldrich Center for Workforce Development at Rutgers University, told members of Congress in March 2009.[29]

One national company that illustrates the potential of the clean energy economy is Hemlock Semiconductor,[30] the world's largest producer of polysilicon, a key material in photovoltaic devices such as solar panels. For decades, the 48-year-old company primarily produced semiconductors, but solar panels have taken off, and Hemlock with them. The company, based in Hemlock, Michigan, has expanded rapidly during the past five years—doubling from 600 to 1,200 employees. In December 2008, Hemlock announced a $1.2 billion investment to launch a new Clarksville, Tennessee, plant that will employ 900 people once it opens in 2012. Tennessee Governor Phil Bredesen and the Tennessee Department of Economic and Community Development created an attractive package to lure Hemlock, including tax incentives, a shovel-ready location, and sound roads and other transit to ship materials in and products out. The package also featured a partnership with Austin Peay State University, which committed to offering a program to train skilled manufacturing workers in meeting the specific needs of a company such as Hemlock.[31]

"As the solar industry grows domestically and internationally, we'd expect both of our sites [in Michigan and Tennessee] to continue to grow," said Jarrod Erpelding, a company spokesman. "We have this tremendous operation set up to serve the world's solar electricity generation needs. But solar comprises less than 1 percent of the world's total electricity generation. We're as large as we are now to serve this very small fraction. We are working as hard as we can to grow the domestic market for solar energy."

Where the Jobs Are Now, and Where They Are Heading

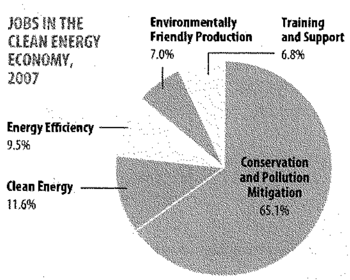
The Jobs of Today: Conservation and Pollution Mitigation. In 2007, 65 percent—501,551—of all jobs in the clean energy economy were in the category of Conservation and Pollution Mitigation, which includes the recycling industry (Exhibit 3). These jobs are spread across all 50 states and the District of Columbia. The industries and businesses represented in this sector are capital intensive—requiring large investments in plants and equipment—and they respond to the demand to recycle and reuse water and other natural resources more efficiently. The dominance of this sector to date makes sense, given recognition among consumers, policy makers and business leaders of the need to recycle waste, conserve water and mitigate emissions of greenhouse gases and other pollutants.[32]

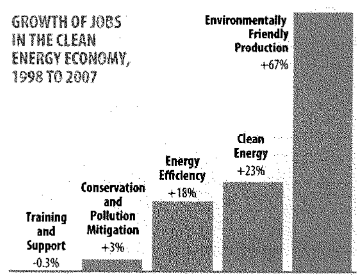
EXHIBIT 3

THE U.S. CLEAN ENERGY ECONOMY:

Jobs of Today and Jobs of Tomorrow

65 percent of today's clean energy economy jobs are in the category of Conservation and Pollution Mitigation. Growing recognition among the public, policy makers and business leaders of the need to recycle waste, conserve water and work to mitigate emissions of greenhouse gases and other pollutants has led to growth in this category. But growth trends paint a different picture for the future of the clean energy economy. Jobs in Environmentally Friendly Production, Clean Energy and Energy Efficiency are growing much faster in response to new market demands.





SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

A CONSERVATION AND POLLUTION MITIGATION FIRM: RECYCLEBANK

To be cost effective for municipalities, recycling must occur on a large enough scale to yield savings at the landfill.

RecycleBank, which operates in 18 states and 100 cities and towns, encourages recycling while helping consumers and local governments save money.[33] The company collects recyclable materials in bins equipped with computer chips that record the amount recycled and send the information to the RecycleBank's Web site, where it is converted into points for the bin owner's account. The customer can log into the account and convert points to coupons for stores such as Target and brands such as Kraft.

As a result of these incentives, areas that use the program have seen recycling increase by 50 percent or more along with significant savings at the landfill, which often charge per ton.[34] Wilmington, Delaware, for instance, cut its $2.1 million annual waste removal tab by 40 percent.[35]

RecycleBank's roughly 105 employees include operations managers, technology specialists, marketing professionals and salespeople. The staff does not include truck drivers, garbage collectors or recycling plant workers because the company tries to help existing recycling operations stay in business. Once a deal is signed, RecycleBank retrofits existing trucks with mechanical arms that read the chips in the new bins. Upfront costs are paid by RecycleBank in return for an agreement to share the long-term savings with the city.[36]

Some communities are not traditionally recyclers—especially low-income areas where it is not easy for individuals without the means to invest in solar panels, electric cars and the like. But RecycleBank CEO Ron Gonen said the company has done well in these neighborhoods. "We've been able to come in on a mass scale and say we're going to help you become part of this environmental movement today, and we're going to reward you for it," Gonen said. "If you give people the opportunity, they're going to take advantage of it."[37]

The Jobs of Tomorrow: Clean Energy; Energy Efficiency; and Environmentally Friendly Production. While the Conservation and Pollution Mitigation sector contains the majority of today's jobs and businesses in the clean energy economy, Pew's data indicate that three different categories represent the jobs of tomorrow: Clean Energy; Energy Efficiency; and Environmentally Friendly Production. Together, these categories make up more than one in four jobs in today's clean energy economy—and they are growing at a fast clip. They represent businesses and jobs that are looking ahead to develop renewable, efficient energy sources and technologies to meet the demands of a carbon-constrained economy (Exhibit 3).

Clean Energy. The Clean Energy sector contains a variety of different workers, from electricians and engineers to plumbers, who help create, distribute and store clean, renewable energy. In 2007, this sector accounted for about 89,000 jobs. While this category is small relative to the more established and geographically dispersed Conservation and Pollution Mitigation sector, it is growing rapidly and promises to form the backbone of tomorrow's clean energy economy. Investors see great potential in this burgeoning sector. As explained below, it attracted the vast majority of clean venture capital between 2006 and 2008. The jobs in this category are located in three main areas: energy generation, transmission and storage.

Nearly six out of 10 jobs in this sector fall specifically in the area of energy generation, which includes jobs responsible for producing clean forms of energy such as wind, solar, geothermal, low-impact hydro, hydrogen, marine and tidal, and small-scale biopower. Jobs responsible for solar power generation dominate this subgroup: 62.5 percent of all energy generation jobs in 2007 were in the solar industry. Jobs in wind power were second overall, making up 9.7 percent of energy generation jobs in 2007, but they grew more rapidly—by 23.5 percent between 1998 and 2007, compared to 19.1 percent growth for solar power jobs during the same period (Exhibit 4).

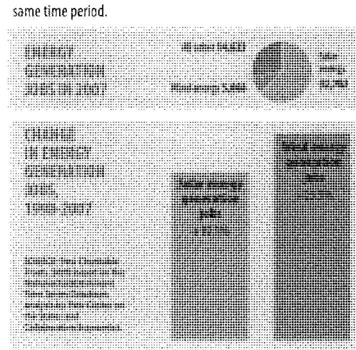
Energy transmission jobs, focused on building tomorrow's energy delivery systems, represent one of every nine jobs in the overall Clean Energy sector. GridPoint, a Virginia-based technology firm with 130 employees, is among the businesses seeking to make those systems smarter. Much of America's electricity grid currently sits unused except at peak times, when the system exceeds capacity. "As we get closer to the consumer, we don't have any ability to measure and control the electricity at that level," said Steven Hauser, head of GridPoint's market development.[38] As a result, the grid is not very smart. Better consumption patterns and pricing signals between producers and end users could change that dynamic, making the grid work optimally and provide better feedback to end users. In March 2008, GridPoint began collaborating with the City of Boulder, Colorado, and other energy companies to make Boulder a smart grid laboratory. Smart meters have been installed in about 15,000 homes—ultimately, about 50,000 will have them—and GridPoint has installed software and other tracking devices to monitor and control energy consumption in real time, allowing consumers and the utility to better understand patterns of energy use. Providers can then price energy accordingly, and consumers can reduce their energy consumption during the most expensive hours. "It is really important that states develop their own smart grid plans—and better green energy plans for that matter—to encourage investment at the state level," said Hauser.

The remaining 31 percent of jobs in the Clean Energy sector concentrate on developing and implementing new and more effective energy storage technologies, such as those that capture excess renewable energy supply and release it on demand. Renewable energy

EXHIBIT 4

SOLAR AND WIND ENERGY

Nearly six out of 10 jobs in the category of Clean Energy are responsible for the generation (versus transmission or storage) of clean and renewable energy. Jobs in solar energy generation account for 62.5 percent of all energy generation jobs. Jobs in wind energy generation are second overall, making up 9.7 percent. Jobs in wind and solar are expanding at promising rates—wind power jobs grew 23.5 percent between 1998 and 2007, outpacing solar jobs, which grew 19.1 percent during the same time period.



A CLEAN ENERGY FIRM
GAMESA

Gamesa, a Spanish-owned wind turbine manufacturer, arrived in Pennsylvania in early 2005. Its first plant was a former U.S. Steel factory in Ebensburg, outside Pittsburgh—and some of its first hires were former steel workers from the old plant. Within a few years, Gamesa opened a second plant in Fairless Hills and a Philadelphia development office. The company currently employs about 1,000 Pennsylvanians.

Gamesa spokesperson Michael Peck said the company was drawn to Pennsylvania by the state's bipartisan legislative commitment to renewable energy, its proximity to large and accessible energy markets, and its native resources—wind, and a large, skilled workforce, the legacy of the once-mighty steel industry.[39] The state's renewable energy portfolio standard—which requires electricity providers to supply at least a certain amount of power from renewable sources—was set earlier and more aggressively than similar policies in other states, an encouraging signal to Gamesa that there would be local demand for its product, Peck said. In addition, Pennsylvania is situated among many other states with large energy demands, limited wind resources or land for wind farm development and renewable portfolio standards, he said. "We've had an opportunity through the challenge that's facing our environment to take this manufacturing DNA and attain world leadership in green energy and manufacturing," Peck said.

sources such as wind and solar power are intermittent, so finding ways to store and transmit energy when the sun is not shining and wind is not blowing is critical.[40]

Energy Efficiency. As U.S. Energy Secretary Steven Chu has said, "maximizing energy efficiency and decreasing energy use will remain the lowest hanging fruit of the next several decades."[41] In 2007, this sector represented approximately 73,000 jobs in the clean energy economy. The jobs and businesses in the Energy Efficiency category work hand-in-hand with those in the Clean Energy sector. Energy-efficient products and services use the current supply of energy more effectively, decreasing Americans' consumption of carbon-emitting energy while clean, renewable energy sources are developed that can meet a greater share of U.S. energy needs.[42] Energy efficiency is one of the most cost-effective ways of reducing the consumption of carbon-emitting energy supplies, and U.S. consumers have responded by increasing demand for more efficient products and services.[43] In 2007 alone, Americans purchased more than 500 million Energy Star® products—labeled as energy efficient by the U.S. Department of Energy and Environmental Protection Agency—across 50 categories, up 67 percent from the previous year.[44]

Increased demand for energy-efficient products and services has spurred job growth for workers who make and distribute software and meters to monitor energy consumption and who manufacture and install efficient glass and lighting, along with service-related jobs that help companies and individuals improve home or business energy use. Many of these jobs are white-collar positions, including energy management and energy consulting services. The two groups are closely connected; the demand for energy-efficient products drives a corresponding demand for energy management and consulting services and related jobs.

AN ENERGY EFFICIENCY FIRM: HONEYWELL

Honeywell International, based in Morris Township, New Jersey, and inventor of the iconic round thermostat found in homes around the world, has a $38 billion portfolio—and nearly half of it is tied to energy efficiency products and services, according to Kent Anson, vice president of Global Energy and Environment for Honeywell Building Solutions.[45] Sales in Honeywell's Automation and Control Solutions division, which includes the Building Solutions section and many energy efficiency products such as sensors and switches for lights and other appliances, jumped at a rate twice that of total company sales in 2008.[46]

In a typical contract, Honeywell engineers audit building systems for potential energy efficiency improvements and oversee comprehensive retrofits that can save thousands of dollars and tons of emissions and create or sustain a range of jobs for Honeywell engineers, local subcontractors and manufacturing workers in supplier companies, said Anson. All told, a $10 million contract can create or sustain 95 jobs, according to the National Association of Energy Services Companies.[47] The audit process often leads to a combination of bringing in renewable energy sources and tightening up the efficiency of sources old and new. For example, a Honeywell contract launched last fall with the Housing Authority of the City of Pittsburgh is expected to save the city $3.2 million annually in utility costs by switching communities to geothermal HVAC systems (systems that store air from the earth's natural heating and cooling processes), sealing buildings to reduce loss of hot and cold air and retrofitting lights and appliances with more efficient models.[48] The improvements also are expected to cut annual carbon emissions by nearly 16 million pounds—equivalent to removing more than 1,300 vehicles from the road.[49] "By developing projects that have environmental and financial drivers, we will see the type of widespread adoption that will have a lasting impact on greenhouse gas emissions," said Anson.[50]

AN ENERGY EFFICIENCY FIRM: JOHNSON CONTROLS

Johnson Controls, a Fortune 500 auto parts manufacturer headquartered in Milwaukee, Wisconsin, is one of the country's fastest-growing companies in the clean energy economy and is a recognized leader in energy-efficient building solutions.[51] In fact, as Joy Clark-Holmes, the company's director of Local Government and Market Solutions explained, growth in its building efficiency business is outpacing its other divisions, accounting for more than one third of the company's 140,000 employees and $38 billion in sales in 2008.[52] "We are benefiting from the expansion of the public's general interest in energy efficiency and its willingness to invest," Clark-Holmes said.

Johnson Controls recently launched a campaign to educate consumers about energy efficiency and sustainability. "'Green' is a marketing word for what people feel is doing the right thing," said Clark-Holmes. "If you truly want to become green you have to become energy efficient."

AN ENERGY EFFICIENCY FIRM: AUSTIN ENERGY

Austin Energy[53] has been actively promoting conservation since 1982, "before it was on everyone's radar," according to spokesman Ed Clark. Its Power Saver program has encouraged customers to make their homes and businesses more energy efficient through rebates and low-interest loans for improvements from weather stripping to solar panel installation. Austin Energy works with 80 independent local heating and air-conditioning services to make the improvements in the Austin, Texas, metropolitan area. In addition, the utility company has a two-year-old partnership with Austin Community College, in which students intern with Austin Energy and other area utilities in preparation for post-graduate jobs.

Austin Energy is a city department. Because it is publicly owned and its profits become part of the city's general fund, every investment the group makes of more than $50,000, such as the purchase of its $2.3 billion biomass plant, must be reviewed and approved by the Austin City Council before it can be implemented. The short-term costs of moving to renewable energy sources can cause concerns for constituents—but energy efficiency and ultimate cost savings to consumers and the city benefit everyone, said Clark. The city council recently passed a new Energy Conservation Audit and Disclosure Ordinance that will go into effect June 1, 2009, requiring energy audits of all homes more than 10 years old before they are sold, and disclosure of the results to prospective buyers. Clark predicted that in addition to increasing the demand for efficiency improvement products and services, the ordinance will create a need for about 100 certified inspectors to perform the audits.[54]

AN ENVIRONMENTALLY FRIENDLY PRODUCTION FIRM: PROJECT FROG

San Francisco, California-based Project FROG (Flexible Response to Ongoing Growth)[55] provides customizable, prefabricated "smart buildings" that incorporate science, technology and human behavior at as much as 40 percent less than the cost of traditional construction projects, according to company founder Mark Miller.[56]

Three years ago, Miller and his colleagues at a San Francisco architecture firm established Project FROG with two goals: to reduce money, time and materials associated with traditional construction and to create efficient, affordable and environmentally neutral buildings.[57] With the support of venture capital firms, they developed prefabricated components to create buildings suited to different sites and user needs. For its first commercial projects, Project FROG targeted American school districts. To date, the company has constructed buildings across two campuses, and it has three more campuses under construction that will open this fall. Project FROG employs a staff of 20 and works with 10 full-time consultants from the architecture, energy, manufacturing and engineering fields. To maintain the brand's low-cost, sustainable ethos, the company buys its materials—primarily steel and large panels that become walls—from local suppliers, and it favors producers that have strong efficiency and sustainability practices in place, said Adam Tibbs, president of Project FROG.

A TRAINING AND SUPPORT FIRM: MANKO, GOLD, KATCHER & FOX

Pennsylvania's Land Recycling Program, which encourages owners of brownfield sites to clean them up by providing uniform standards, liability relief, standardized reviews and financial assistance, is a major source of business for the law firm of Manko, Gold, Katcher & Fox. The firm, which is based in Pennsylvania but represents clients in every state and all over the world, provides legal services related to the Land Recycling Program and other environmental policies. For example, the firm's lawyers counsel businesses and municipalities on compliance with environmental regulations, and they help clients determine whether their projects qualify for environment-related funding through ARRA and other programs. The federal stimulus has boosted demand for environmental legal services as companies and municipalities jostle for funding with "green" stipulations attached to it. Managing Partner Robert Fox predicts the market for environmental lawyers is "going to be much hotter over the next 10 years than it was over the last."[58] Manko Gold's staff includes 28 lawyers and two full-time technical consultants who are experienced engineers.

Environmentally Friendly Production. Ten years ago, relatively few jobs focused on supplying alternative products and services, such as environmentally friendly construction materials and compressed natural gas bus engines, aimed at reducing carbon emissions and conserving natural resources. In 2007, the Environmentally Friendly Production sector comprised 53,700 jobs—7 percent of all jobs in the clean energy economy—but that share reflects growth of 67 percent during the past decade, driven by the transition Americans are making toward more environmentally sustainable products and practices. Products traditionally made from derivatives of fossil fuels are now being produced from organic materials such as complex sugars and starches; the production of these bioproducts has increased and will continue to grow as the demand for fossil fuel replacements grows.

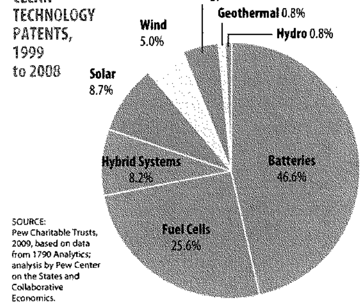
Training and Support. In 2007, there were more than 50,000 jobs in the Training and Support sector, the only category in the clean energy economy that experienced a negative annual growth rate between 1998 and 2007. Employment in this area peaked in 2002 and declined during the next three years, but it has been on the rise again since 2006. Despite its small size and slow growth, the skills and specialized services of the jobs in this category are vital to the other four sectors of the clean energy economy. Teachers train plumbers and electricians to install clean energy systems, researchers develop new energy-generating technologies, and legal and business firms consult with companies to ensure that their products and services thrive in the growing clean energy economy.

Patents and Venture Capital Investments

The clean energy economy is still young. As Pew's data show, jobs and businesses in the clean energy economy have multiplied rapidly during the past decade—yet the numbers reflect early efforts by investors, entrepreneurs, researchers and policy makers. "Clean tech is where IT was 30 years ago and biotech was 20 years ago; we're way earlier in the innovation cycle," said David Prend, managing general

EXHIBIT 5
CLEAN TECHNOLOGY PATENTS

During the past 10 years, clean technology patents have been registered across eight different areas of technology development. A majority of all clean technology patents have been registered in energy storage technologies, including batteries, fuel cells and hybrid systems.



SOURCE: Pew Charitable Trusts, 2009, based on data from 1790 Analytics; analysis by Pew Center on the States and Collaborative Economics.

Patents

Patent registration statistics point to the types of technologies that may be introduced into the market in the coming years (Exhibit 5). Registering a patent to protect and control the technology is one of the most important early steps in bringing an innovation to market.[60] Patents are particularly important for expensive energy generation and advanced energy storage technologies. "Due to large, upfront capital requirements, dependable patent protection is an absolute necessity for the development and commercialization of the job-creating technologies and industries of the future," said William Klehm, president and CEO of Fallbrook Technologies, which designs and manufactures drivetrains for bikes and light electric vehicles.[61] Patents are not only for entrepreneurs who are building a new company around new products; they also enable established businesses to advance their

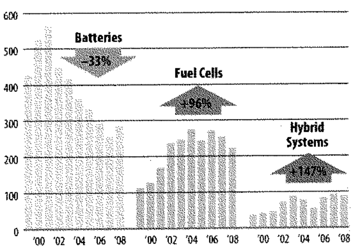
partner at RockPort Capital and director of the National Venture Capital Association. "We're just now starting to see the most exciting, true innovation. It has taken time to attract entrepreneurs and scientists. That's all just starting to hit its stride, with more game-changing opportunities."[59]

Today's research and venture capital spending will generate tomorrow's clean energy opportunities. Innovation drives job growth: New companies can form around a clean technology, and more established firms can respond to new market demands and expand their range of products and services. Pew took a closer look at patent registrations and venture capital investments to get a preview of where the clean energy economy is headed.

EXHIBIT 6
ENERGY STORAGE PATENTS

During the past 10 years, patents for energy storage technologies have accounted for a majority of all clean technology patent registrations. The types of energy storage patents have shifted over time. Traditional battery technologies have been replaced in recent years with growth in fuel cells and hybrid systems.

TRENDS IN ENERGY STORAGE PATENTS, 1999-2008

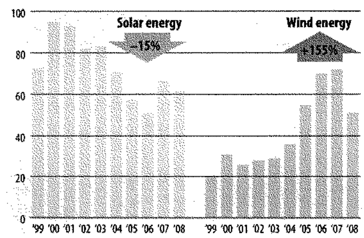


SOURCE: Pew Charitable Trusts, 2009, based on data from 1790 Analytics; analysis by Pew Center on the States and Collaborative Economics.

EXHIBIT 7
WIND AND SOLAR PATENTS

Patents in energy generation—solar, wind, hydro and geothermal—have accounted for less than a fifth of all clean technology patents registered in the past 10 years. Patents for solar technologies have historically dominated, but recently an increasing number of patents have been registered for wind energy technologies.

GROWTH OF WIND AND SOLAR PATENTS, 1999-2008



SOURCE: Pew Charitable Trusts, 2009, based on data from 1790 Analytics; analysis by Pew Center on the States and Collaborative Economics.

existing product lines and gain advantages over their competition.

Between 1999 and 2008, 8,384 clean energy technology patents were registered in the United States. Although traditional battery technology patents have accounted for nearly half of all registered clean energy technology patents in the last 10 years, registrations for hybrid systems and fuel cells[62] have begun to gain ground (Exhibit 6). Among clean energy generation patents—which have accounted for 15.3 percent of all patents registered in the past 10 years—solar technologies historically have outpaced other parts of the sector, but they have declined in recent years as the solar industry has begun to focus more on implementing and scaling up existing technologies rather than creating new ones. The number of wind technology patents has climbed rapidly (Exhibit 7). Geothermal and hydro technology patents have accounted for a small number of overall patents—only 1.6 percent thus far—but their growth and the growth in wind patents demonstrate burgeoning private-sector interest in a diverse renewable energy portfolio.

Venture Capital

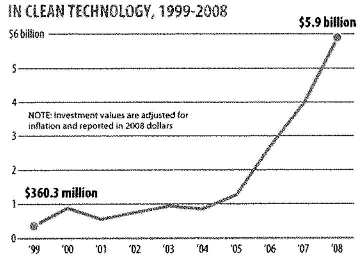
Tracking venture capital investments across all 50 states shows where investors see market opportunities. Beginning in 2006, venture capital investments in businesses that are drivers of the clean energy economy grew dramatically, increasing annually by an average of $1.6 billion (Exhibit 8). In fact, in 2008 clean venture capital investments accounted for 15 percent of all global venture capital investments, up from 9 percent in 2007,[63] and domestic clean venture capital investments outpaced international investments.[64] In 2008 alone, investors directed $5.9 billion into American businesses in the clean energy economy, a 48 percent increase over 2007 investment totals.

Given the national recession, the news was not as encouraging in the last quarter of 2008 and first quarter of 2009. In April, the Cleantech Group reported that investments in clean technology were down 48 percent in the first three months of 2009, compared with a year earlier.[65] But clean tech actually fared better than other industries: Total venture capital across all sectors for the first quarter of 2009 was down 61 percent from the first quarter of 2008, according to the National Venture Capital Association.[66] The Cleantech Group projects that clean technology investments will rebound quickly. "The long-term drivers for cleantech are still intact," the group reported in April 2009. These include the growing demand for energy services, the stress on water supplies, the need to reduce

EXHIBIT 8
VENTURE CAPITAL INVESTMENTS

Since 2006, venture capital investments in clean technology businesses have grown dramatically. Between 2006 and 2008, investments increased by an average of $1.5 billion annually. In 2008 alone, $5.9 billion of venture capital was invested in clean technology businesses.

VENTURE CAPITAL INVESTMENTS IN CLEAN TECHNOLOGY, 1999-2008



SOURCE: Pew Charitable Trusts, 2009, based on data from The Cleantech Group™ LLC; analysis by Pew Center on the States and Collaborative Economics.

Venture capital is an essential source of private equity for emerging technologies. For business startups in the clean energy economy, it is indispensable. "You have to have VC backing in order to bring the product to commercialization," said Tibbs, president of Project FROG. "It's what greases the wheel." Unlike many other types of investors, venture capitalists target early-stage companies and cutting-edge technologies with high growth potential. They are willing to take significant risks in exchange for potentially substantial gains.

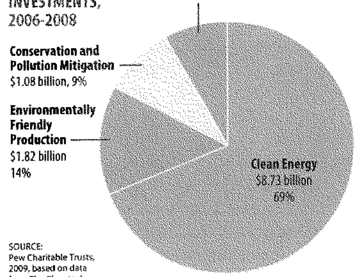
Innovation in the form of new clean energy technologies is neither cheap nor easy. For greenhouse gas emissions, and a limited supply of traditional fossil fuels, according to the report.[67] "It's important not to miss the forest for the trees," Nicholas Parker, executive chairman of the Cleantech Group, said in January 2009. "In 2008, there was a quantum leap in talent, resources and institutional appetite for clean technologies. Now, more than ever, clean technologies represent the biggest opportunities for job and wealth creation."[68]

Investments in Clean Energy companies accounted for 69 percent of all clean venture capital investments between 2006 and 2008 (Exhibit 9). In fact, 54 percent of all investments have gone to energy generation companies alone. Many of those dollars went to solar technologies; in 2008, funding for solar companies accounted for 40 percent of all venture capital raised globally for businesses in the clean energy economy.[69]

EXHIBIT 9
AREAS OF VENTURE CAPITAL INVESTMENT

Venture capital funding in clean technology over the last three years has totaled nearly $12.6 billion. Investments in Clean Energy companies dominated all venture capital investments, accounting for 69 percent of investments between 2006 and 2008. Companies in Environmentally Friendly Production and Conservation and Pollution Mitigation attracted more than $2 billion in investment during the same time period.

CLEAN VENTURE CAPITAL INVESTMENTS, 2006-2008



SOURCE: Pew Charitable Trusts, 2009, based on data from The Cleantech Group™ LLC; analysis by Pew Center on the States and Collaborative Economics.

NOTE: Investment values are adjusted for inflation and reported in 2008 dollars. The category of Training and Support is not represented because it is not a category of investments tracked by The Cleantech Group LLC.

every breakthrough, hundreds more fall short, necessitating ongoing, capital-heavy investments in research and development. Still more capital is required to bring them to market at a scale that makes them competitive with carbon-intensive forms of energy. "Energy is a $6 trillion market worldwide. It is the mother of all markets," John Doerr, a partner at Kleiner Perkins Caufield & Byers, one of the country's largest venture capital firms, told the nation's governors in February 2008.[70] "Our investments, our policies, and our government R&D must match the scale of this problem. And we've got to work together: If we don't scale, we're going to fail."

For example, Solyndra, a Fremont, California-based solar company, developed and patented technology for commercial rooftops that captures more hours of optimal sunlight per day and allows the panels to lie flat instead of on an angle, making installation easier and less expensive.[71] Recognizing the commercial viability and scalability of the technology, venture capital firms have poured more than $920 million into the company since its founding in 2005.[72] Investments also have enabled aggressive research and development; Solyndra tested its manufacturing processes at the National Renewable Energy Laboratory through a public-private partnership with the federal government.[73]

In March 2009, Solyndra became the first beneficiary of the U.S. Department of Energy's loan-guarantee program, introduced in 2005 to encourage the development and adoption of new clean energy technologies.[74] The $535 million loan guarantee will enable the company to build a second factory in Fremont. Solyndra CEO and founder Chris Gronet said the additional funding will help the company achieve the economies of scale needed to deliver solar electricity at prices that are competitive with utility rates.[75] These economies of scale also mean more jobs. The new plant will employ 1,000 full-time employees upon its completion, and 3,000 construction workers will be put to work immediately to build it. Solyndra representatives expect their product to be cost-competitive with coal in the next two to three years.[76]

A VENTURE CAPITAL FIRM: MOHR DAVIDOW VENTURES

Will Coleman's venture fund, Mohr Davidow Ventures, with $2 billion under management, is putting money into emerging energy generation technologies for a pragmatic reason: it believes there's a lot of money to be made there. "Cleantech venture capital is not a mission-driven business," said Coleman, a partner at Mohr Davidow. "It's focused on real opportunities and real markets. We wouldn't be here investing if we didn't believe that."[77]

"Cleantech venture capital is not a mission-driven business... It's focused on real opportunities and real markets. We wouldn't be here investing if we didn't believe that."

—Will Coleman
Mohr Davidow Ventures

Mohr Davidow Ventures, based in Menlo Park, California, focused exclusively on Internet-related technology investments when it was created in the 1980s, and has since broadened its portfolio to include technologies related to the life sciences, and, most recently, businesses in the clean energy economy. The firm's current investments include support for Nanosolar, a solar panel manufacturer in California, and Hycrete, a developer of more sustainable construction materials.[78]

Coleman said he pays close attention to a company's location when deciding whether to invest. The state's policy climate plays a major role in his decision, he said, and he is interested in everything from potential tax incentives to the existence of a strong renewable portfolio standard, which he said helps create market stability. He also believes government investments are essential to stimulate and support the research and development that is necessary before technological innovations can be brought to market. "We play a catalyzing role in developing technologies that can be deployed commercially," he said. "But in order to do that you have to have a deep pool of research and development going on in universities and other research centers. The opportunities for us really depend on the health and depth of those pools."

The Clean Energy Economy: State-By-State Numbers

Jobs

Every state and the District of Columbia have a piece of the 770,385 jobs and 68,203 businesses in America's clean energy economy (see Exhibit 1, page 8). Yet no two states look the same in terms of the type or number of jobs. For example, California has more jobs in the clean energy economy than any other state—more than 125,000—a number that grew annually by an average of 0.9 percent between 1998 and 2007. Wyoming has the fewest of these jobs nationally, at just more than 1,400, but they have grown annually by an average of 5.2 percent, indicating strong momentum and potential.

Each state has different competitive advantages when it comes to growing jobs and businesses in the clean energy economy, attracting private venture capital investments and incubating research and development. Some states have abundant natural resources such as wind and sunshine, while others are home to dozens of research universities. What is important is that policy makers understand and capitalize on their states' unique strengths to expand their share of the clean energy economy.

Pew conducted three analyses to provide an effective way of comparing states' clean energy economies. First, we looked at the total number of jobs in each state's clean energy economy in 2007 and the annual growth rate of those jobs between 1998 and 2007. Second, we looked at the total number of jobs in the clean energy economy in the context of each state's total jobs, which presents a baseline understanding of how the clean energy sector relates to overall economic performance in the states. And third, we compared the growth rate of jobs in each state's clean energy economy to the growth rate of its overall jobs. Looking ahead, these analyses offer lawmakers, business leaders and the public a way to measure the return on investment of current and future clean energy policy decisions.

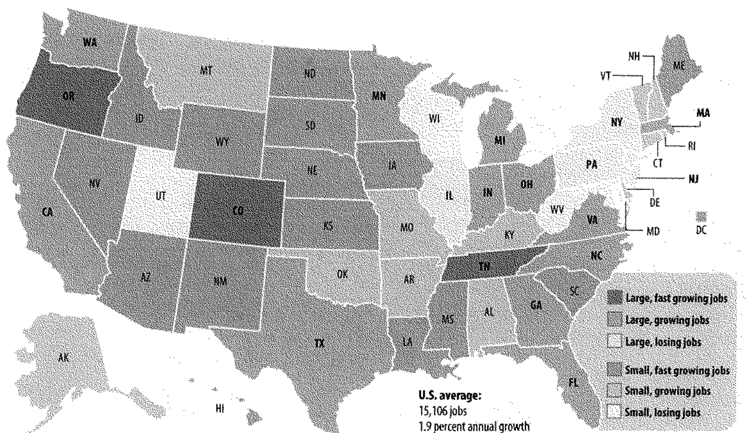
Analysis One: States' Clean Energy Economies—How Big Are They, and How Fast Are They Growing?

Looking simultaneously at the total number of jobs and businesses (large or small) and average annual growth rate of the jobs (fast growing, growing or losing), states' clean energy economies fall into six groups: large and fast growing, growing or losing; and small and fast growing, growing or losing (Exhibit 10).

Large and fast growing. Three states have large and fast-growing clean energy economies: Colorado, Oregon and Tennessee. In 2007, each of these states exceeded the national averages for both the number of jobs in the clean energy economy (15,106) and the average annual growth rate for those jobs (1.9 percent). These states are geographically dispersed, demonstrating that location is not the sole factor in the success and

EXHIBIT 10
WHERE ARE THE JOBS IN THE CLEAN ENERGY ECONOMY?

Looking simultaneously at the total number of jobs (large or small) and their average annual growth rate (fast growing, growing or losing), states' clean energy economies fall into six groups: large and fast-growing jobs, growing jobs or losing jobs; and small and fast-growing jobs, growing jobs or losing jobs. Large states had more jobs in their clean energy economies in 2007 than the national average of 15,106 jobs. Small states had fewer than the national average of clean energy economy jobs. States with fast-growing clean energy economies experienced average annual growth between 1998 and 2007 that exceeded the national average of 1.9 percent. Growing states had a positive average annual rate of growth less than 1.9 percent and losing states have experienced negative growth.



STATE	TOTAL CLEAN JOBS 2007	AVG. ANNUAL GROWTH 1998-2007	STATE	TOTAL CLEAN JOBS 2007	AVG. ANNUAL GROWTH 1998-2007	STATE	TOTAL CLEAN JOBS 2007	AVG. ANNUAL GROWTH 1998-2007
Alabama	7,849	0.31%	Kentucky	9,308	1.09%	North Dakota	2,112	3.17%
Alaska	2,140	1.14	Louisiana	10,641	2.06	Ohio	35,267	0.85
Arizona	11,578	2.19	Maine	6,000	2.34	Oklahoma	5,465	0.89
Arkansas	4,597	0.99	Maryland	12,908	−0.11	Oregon	19,340	4.77
California	125,390	0.88	Massachusetts	26,678	0.52	Pennsylvania	38,763	−0.48
Colorado	17,008	1.98	Michigan	22,674	1.20	Rhode Island	2,328	0.37
Connecticut	10,147	1.11	Minnesota	19,994	1.38	South Carolina	11,255	3.56
Delaware	2,368	0.23	Mississippi	3,200	2.57	South Dakota	1,636	7.89
District of Columbia	5,325	2.13	Missouri	11,714	0.71	Tennessee	15,507	2.14
Florida	31,122	0.90	Montana	2,155	0.15	Texas	55,646	1.70
Georgia	16,222	1.18	Nebraska	5,292	10.00	Utah	5,199	−1.31
Hawaii	2,732	4.29	Nevada	3,641	3.15	Vermont	2,161	1.69
Idaho	4,517	10.11	New Hampshire	4,029	0.44	Virginia	16,907	0.66
Illinois	28,395	−0.25	New Jersey	25,397	−1.08	Washington	17,013	0.23
Indiana	17,298	1.88	New Mexico	4,815	4.73	West Virginia	3,065	−0.36
Iowa	7,702	2.66	New York	34,363	−0.14	Wisconsin	15,089	−0.55
Kansas	8,017	4.74	North Carolina	16,997	1.62	Wyoming	1,419	5.16

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

vitality of a state's clean energy economy. Tennessee has had success developing jobs in the Conservation and Pollution Mitigation category, which includes recycling, waste treatment and water management; more than three quarters of the state's jobs in the clean energy economy are in this category. Colorado has capitalized on its natural wind and sun resources to stimulate job growth in Clean Energy, while Oregon has become a leader in Energy Efficiency, with a quarter of its jobs in the clean energy economy in this category.

Large and growing. Twelve states have large and growing clean energy economies: Their numbers of jobs in the clean energy economy in 2007 exceeded the national average and have grown by an average of 1 percent annually. These states' clean energy economies are expanding at a moderate but steady rate, and they have a strong foundation on which to build. These states are California, Florida, Georgia, Indiana, Massachusetts, Michigan, Minnesota, North Carolina, Ohio, Texas, Virginia and Washington.

Large and losing. Illinois, New Jersey, New York and Pennsylvania have large clean energy economies that are losing jobs. Difficult economic conditions have led to a net loss of these jobs in these four states during the past 10 years. Still, Illinois, New Jersey, New York and Pennsylvania each rank among the top 10 states for total jobs in the clean energy economy across several of Pew's five categories (Exhibit 11).

Small and fast growing. Comprising the largest group, 15 states and the District of Columbia are categorized as having small and fast-growing clean energy economies. These states had fewer than the national average of jobs in the clean energy economy in 2007 but exceeded the national average for annual rate of job growth. For example, Idaho and South Dakota each had fewer than 5,000 of these jobs, but their average annual growth rates are among the top in the nation at 10.1 percent and 7.9 percent, respectively. The other 13 states are Arizona, Hawaii, Iowa, Kansas, Louisiana, Maine, Mississippi, Nebraska, Nevada, New Mexico, North Dakota, South Carolina and Wyoming.

Small and growing. Another 12 states have small and growing clean energy economies, with fewer than average jobs and some annual job growth, although their rates of growth—less than 2 percent—lag behind states with similarly sized clean energy economies. These states are Alabama, Alaska, Arkansas, Connecticut, Delaware, Kentucky, Missouri, Montana, New Hampshire, Oklahoma, Rhode Island and Vermont.

Small and losing. Maryland, Utah, West Virginia and Wisconsin had fewer than average jobs in the clean energy economy in 2007 and experienced net losses in these jobs during the past 10 years. In Maryland, at least, that trend may change in coming years. New legislation that aims to reduce greenhouse gas emissions by 25 percent by 2020 was enacted by Maryland lawmakers in May 2009, and it may drive greater demand for environmentally friendly products and services in the state.[79]

Analysis Two: States' Clean Energy Economies as a Share of Their Overall Economies

Jobs in the clean energy economy accounted for 0.49 percent of all jobs nationally in 2007. Twenty-two states exceeded that U.S. average, including several by a large margin (Exhibit 12). Oregon led the nation with just more than 1 percent of all of its jobs focused on the clean energy economy in 2007. Although Maine had just 6,000 jobs in the clean energy

EXHIBIT 11

STATE LEADERS IN JOBS ACROSS THE CLEAN ENERGY ECONOMY BY CATEGORY

Although California leads in overall employment in each category, a closer look reveals other notable trends. Arizona makes the top 10 in Clean Energy but in no other category. Massachusetts, New York and Ohio are among the top 10 in all but one category.

While Arizona, Arkansas, Iowa, Maine, Nebraska, Wisconsin and the District of Columbia each have fewer than 15,106 jobs in the clean energy economy—the national average—they rank among the top 10 states in one of the five categories. In all, nearly half the states rank among at least the top 10 states in at least one category of the clean energy economy.

Clean Energy	JOBS 2007	Energy Efficiency	JOBS 2007	Environmentally Friendly Production	JOBS 2007	Conservation and Pollution Mitigation	JOBS 2007	Training and Support	JOBS 2007
California	27,672	California	10,510	California	13,666	California	64,799	California	8,743
Pennsylvania	10,099	Texas	6,353	Minnesota	3,815	Texas	40,617	New York	3,499
Minnesota	4,030	Ohio	5,367	Oregon	3,304	Pennsylvania	24,703	Illinois	3,216
Ohio	3,653	Oregon	4,893	Ohio	2,800	Florida	24,686	Massachusetts	3,155
Texas	3,479	New York	3,311	Iowa	2,237	New York	23,082	District of Columbia	3,130
New York	3,421	Wisconsin	2,801	Texas	2,223	Ohio	22,296	Texas	2,974
Michigan	2,941	Maine	2,560	Nebraska	2,162	New Jersey	20,060	Florida	2,249
Massachusetts	2,890	Massachusetts	2,553	Illinois	1,921	Illinois	19,631	Virginia	1,755
District of Columbia	2,728	Virginia	2,135	Colorado	1,361	Massachusetts	17,374	Pennsylvania	1,742
Colorado	2,639	Florida	2,071	Arkansas	1,303	Michigan	15,852	North Carolina	1,659

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

economy as of that year, it was a close second with 0.85 of its overall jobs dedicated to the clean energy economy. At the other end of the spectrum, 0.24 percent of Mississippi's total jobs were part of the clean energy economy in 2007, although the state's number of jobs in this area was growing.

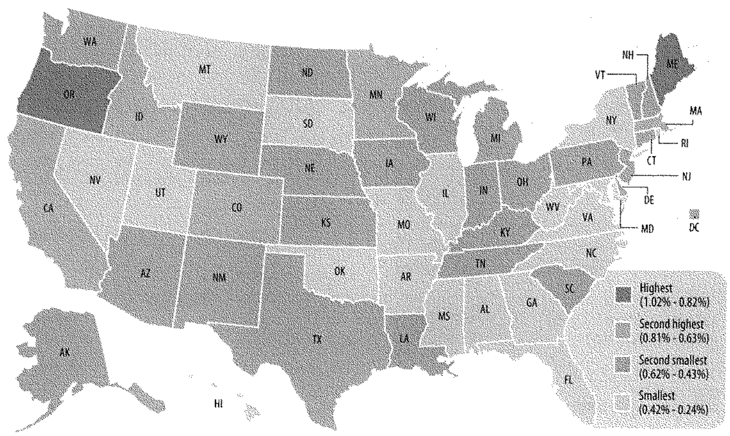
Analysis Three: Growth of Jobs in the Clean Energy Economy Compared with Overall Jobs Growth

Nationally, jobs in the clean energy economy grew by an average of 1 percent annually during the past 10 years, while total employment grew by an average of 0.4 percent annually. In 38 states and the District of Columbia, job growth in the clean energy economy outperformed total job growth between 1998 and 2007. In a number of states, job gains in the clean energy economy have helped lessen total job losses.

Job growth in the clean energy economy eclipsed growth for all jobs by more than 2 percent in 11 states: Hawaii, Idaho, Iowa, Kansas, Mississippi, New Mexico, North Dakota, Oregon, South Carolina, South Dakota and Wyoming. Oregon's large and fast-growing clean energy economy, for example, has dwarfed the growth of overall jobs in the state, expanding by an average of 4.8 percent compared with an average of less than 1 percent annually. This growth is not limited to one industry or job type: Oregon's jobs in the clean energy economy have experienced marked growth during the past 10 years in all five of Pew's categories. And although North and South Dakota have very small clean energy economies, the growth of these jobs in both states has outpaced their growth of total jobs. In North Dakota, overall jobs grew by 1.0 percent, but jobs in the clean energy economy grew by an average of 3.2 percent. In South Dakota, overall jobs grew by

CLEAN ENERGY ECONOMIES AS A SHARE OF STATES' OVERALL ECONOMIES

It is important for states to know just how many of their total jobs fall within the clean energy economy. Nationally, jobs in the clean energy economy accounted for 0.49 percent of all jobs in 2007; 22 states exceeded that national average.



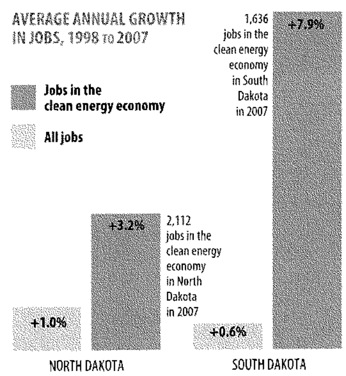
	TOTAL JOBS	PERCENT CLEAN
Alabama	2,193,589	0.36%
Alaska	388,361	0.55
Arizona	2,661,437	0.44
Arkansas	1,366,809	0.34
California	17,556,872	0.71
Colorado	2,668,069	0.64
Connecticut	2,150,723	0.47
Delaware	502,773	0.47
District of Columbia	1,021,958	0.52
Florida	9,903,922	0.31
Georgia	4,955,677	0.33
Hawaii	651,894	0.42
Idaho	718,373	0.63
Illinois	6,792,326	0.42
Indiana	3,348,351	0.52
Iowa	1,800,264	0.43
Kansas	1,531,164	0.52
Kentucky	2,069,602	0.45%
Louisiana	2,326,888	0.46
Maine	707,195	0.85
Maryland	3,108,256	0.42
Massachusetts	3,870,356	0.69
Michigan	5,279,234	0.43
Minnesota	3,143,012	0.64
Mississippi	1,356,603	0.24
Missouri	3,178,657	0.37
Montana	512,093	0.42
Nebraska	1,038,673	0.51
Nevada	1,280,532	0.28
New Hampshire	735,051	0.55
New Jersey	4,957,892	0.51
New Mexico	970,632	0.50
New York	9,964,700	0.34
North Carolina	4,629,118	0.37
North Dakota	422,054	0.50%
Ohio	6,304,302	0.56
Oklahoma	1,784,492	0.31
Oregon	1,902,294	1.02
Pennsylvania	6,542,137	0.59
Rhode Island	549,754	0.42
South Carolina	2,059,151	0.55
South Dakota	444,659	0.37
Tennessee	3,144,614	0.49
Texas	11,726,811	0.47
Utah	1,291,211	0.40
Vermont	365,646	0.59
Virginia	4,238,337	0.40
Washington	3,098,042	0.55
West Virginia	792,474	0.39
Wisconsin	3,150,000	0.48
Wyoming	302,245	0.47

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

an average of only 0.6 percent annually, while jobs in the clean energy economy grew by an average of 7.9 percent during the past 10 years (Exhibit 13).

EXHIBIT 13
THE CLEAN ENERGY ECONOMIES OF THE DAKOTAS

North Dakota and South Dakota have very small clean energy economies. The number of jobs in the clean energy economy in each state was less than 2,200 in 2007. Despite the small overall size of their clean energy economies, the growth of these jobs in both states outpaced their growth of total jobs between 1998 and 2007. In North Dakota, overall jobs grew by 1.0 percent, but jobs in the clean energy economy grew by an average of 3.2 percent annually over the past 10 years. In South Dakota, overall jobs grew by an average of only 0.6 percent annually, while jobs in the clean energy economy grew by an average of 7.9 percent during the past 10 years.



SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

Job growth in the clean energy economy has had a slight edge over total job growth in 18 states: Alabama, Arizona, Arkansas, California, Colorado, Kentucky, Louisiana, Maine, Minnesota, Missouri, Nevada, North Carolina, Oklahoma, Rhode Island, Tennessee, Texas, Vermont and Washington. The difference between the average annual growth of jobs in the clean energy economy and total jobs is less than 2 percentage points in these states. The growth trends in these 18 states underscore the fact that jobs in the clean energy economy are an important contributor to states' fiscal health and a growing source of employment.

Seven states—Connecticut, Delaware, Indiana, Massachusetts, Michigan, Nebraska and Ohio—and Washington, D.C., suffered overall job losses but gained jobs in the clean energy economy between 1998 and 2007. In Nebraska, for example, total jobs have remained relatively constant, declining slightly by an average of 0.5 percent annually, but during the same time period, jobs that are part of the clean energy economy increased rapidly, growing an average of 10 percent. The federal government wants to replicate this pattern nationwide with its tens of billions in energy-related stimulus spending, designed to help replace some lost jobs with new ones that are part of the clean energy economy.[80]

Finally, in New York and Illinois, both clean energy economy jobs and overall jobs had negative growth rates between 1998 and 2007, although clean energy economy job growth shrank at a slower rate.

Venture Capital

Venture capital investments help drive states' clean energy economies, allowing companies to grow, hire new employees and scale up the production and distribution of goods and services (Exhibit 14). Clean startups began attracting venture capital in the 1990s, a trend that accelerated in recent years. By 2006, clean investments had become a significant force in the world of venture capital, and between 2006 and 2008, 40 states and the District of Columbia attracted venture capital investments. See Appendix E for the 50-state table.

California was by far the largest recipient of venture capital investments, attracting more than $6.5 billion between 2006 and 2008. Most of the states that attracted venture capital investments have either large and fast-growing or large and growing clean energy economies. The number of jobs in the clean energy economy a state has, and how fast that number is growing, are signals to potential investors—both public and private—of promising market opportunities. That said, venture capital is important but not essential to a state's ability to develop strong industries in the clean energy economy; existing technologies offer potential for growth and are not as reliant on venture capital investment. Ten states have not attracted venture capital funding during the past three years but have developed jobs and businesses in the clean energy economy: Alabama, Alaska, Kentucky, Louisiana, Maine, Montana, Nebraska, North Dakota, South Carolina and South Dakota. Some of these states, such as Kentucky, Maine and North Dakota, have noteworthy shares of jobs in the Clean Energy and Energy Efficiency categories, which accounted for 81 percent of venture capital in the clean technology sector in 2008—meaning that they may be well positioned to attract venture capital funds in the future.

Patents

The states that led in patent registrations between 1999 and 2008 also led in venture capital funding and overall employment. Technology patents help states pioneer new clean products and incubate research and development to help stimulate businesses and jobs in the clean energy economy within their borders. All 50 states and the District

THE POWER OF A STATE'S RESEARCH INVESTMENT: SOUTH CAROLINA

Dr. Kenneth Reifsnider directs the University of South Carolina's Solid Oxide Fuel Cell program, which designs processes that convert chemical energy to electrical power. Hydrogen happens to be the fuel that Reifsnider specializes in, but he does not believe in a single solution to cleaner, alternative energy needs. His work aims to answer the question, "How can we use energy in its many forms?"[81]

Reifsnider's program is just one component of the university's Future Fuels initiative, which develops cleaner energy options, including solar and hydrogen, to successfully replace fossil fuels. The University of South Carolina has established partnerships with 15 private companies, the Savannah River National Laboratory and the City of Columbia, South Carolina, to bring scientists and engineers together to determine how future fuels can be integrated into everyday lives. The State of South Carolina has invested more than $11 million in this comprehensive research partnership, which has made it a national leader among states in future fuel technology. In 2009, Columbia hosted the National Hydrogen Association's annual conference, at which the city showcased its fuel cell district—the first in the southeast—and a hybrid-electric fuel cell bus that begins service this fall. Those and other activities have drawn Reifsnider and other top researchers to South Carolina's program. "This is the very best place to make a step forward," said Reifsnider.[82]

of Columbia have had at least one registered clean technology patent in the past 10 years. Exhibit 15 shows the 10 states with the highest number of patent registrations from 1999 to 2008. See Appendix E for the 50-state table.

EXHIBIT 14 VENTURE CAPITAL INVESTMENTS

Top 10 states attracting venture capital investments in companies in the clean energy economy, 2006-2008. In millions.

California	$6,580
Massachusetts	1,278
Texas	717
Washington	635
Colorado	622
Maryland	324
New Jersey	283
Pennsylvania	233
New York	210
Georgia	180

NOTE: Investment values are adjusted for inflation, reported in 2008 dollars and rounded to the nearest $1,000,000.

SOURCE: Pew Charitable Trusts, 2009, based on data from The Cleantech Group™ LLC; analysis by Pew Center on the States and Collaborative Economics.

EXHIBIT 15 CLEAN TECHNOLOGY PATENTS

Top 10 states in clean technology patent registrations 1999-2008

California	1,401
New York	909
Michigan	749
Texas	414
Connecticut	404
Massachusetts	384
Ohio	309
Illinois	297
Georgia	256
New Jersey	248

SOURCE: Pew Charitable Trusts, 2009, based on data from 1790 Analytics; analysis by Pew Center on the States and Collaborative Economics.

Public Policy and the Future of the Clean Energy Economy

Policies intended to advance the clean energy economy—from comprehensive energy plans, renewable energy standards, energy efficiency measures and tailpipe reduction requirements to the development of alternative fuels, job retraining and waste reduction efforts—have been adopted or are being actively considered by both the federal government and states. It is too early to tell to what degree these efforts will succeed in stimulating U.S. job growth, strengthening America's competitiveness, curbing pollution and conserving resources, or which approaches are particularly effective. But Pew's analysis indicates that they have great potential because they create significant incentives for both the private and public sectors to develop new technologies, infrastructure and processes for clean energy, efficiency and conservation.

State Policies

Although every state has a piece of today's clean energy economy, clear winners and losers will emerge going forward. Policy makers who act quickly and effectively could see their states flourish, while others may lose opportunities for new jobs, businesses and investments. "The keys to our economic potential as a state and as a country—not to mention our survival as a species—will likely rest in our ability to unlock, harness and advance green technologies," Maryland Governor Martin O'Malley told his state's Clean Energy Center in March 2009.[83]

Financial Incentives: Every state offers some form of financial incentive to drive its clean energy economy. Thirty-two states provide residential, commercial and industrial loan financing for the purchase of renewable energy or energy efficiency systems or equipment. Twenty-three states and the District of Columbia offer rebate programs to promote the installation of renewable energy systems and energy efficiency measures such as solar water beating and photovoltaic systems. Forty-six states offer some form of tax incentive to encourage residents and corporations to use renewable energy or adopt energy efficiency systems and equipment.[84]

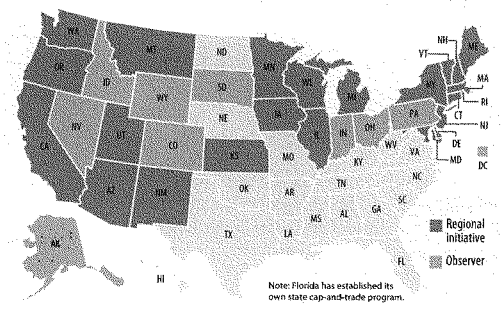
Regional Clean Energy Initiatives: States have banded together to develop regional initiatives to reduce carbon dioxide emissions from power plants, increase renewable energy generation, track renewable energy credits and research and establish baselines for carbon sequestration. Regional initiatives can be more efficient than programs at the state level, because they encompass broader geographic areas and create more uniform regulatory environments. Twenty-three states are members of three major regional initiatives: (1) Midwestern Greenhouse Gas Reduction Accord (MGGRA); (2) Regional Greenhouse Gas Initiative (RGGI); and (3) Western Climate

EXHIBIT 16
STATES' CLEAN ENERGY POLICIES

Regional Initiatives

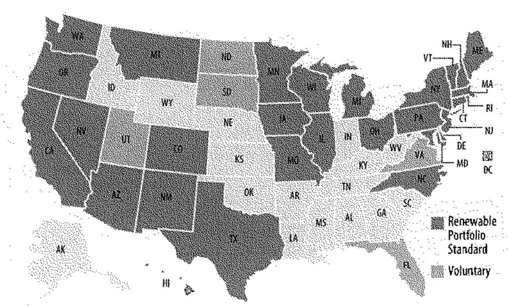
States have banded together to develop regional initiatives to reduce carbon dioxide emissions, increase renewable energy generation, track renewable energy credits and research and establish baselines for carbon sequestration. Twenty-three states are members of three major regional initiatives*. Nine additional states and the District of Columbia are observers of regional initiatives. Florida has established its own individual state cap-and-trade program.

* Midwestern Greenhouse Gas Reduction Accord (MGGRA); Regional Greenhouse Gas Initiative (RGGI); and Western Climate Initiative (WCI).



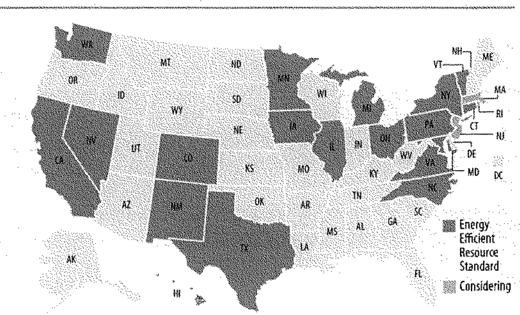
Renewable Portfolio Standards

Twenty-nine states and the District of Columbia have established renewable portfolio standards requiring electricity providers to supply a minimum percentage or amount of customer power from a renewable source of electricity. Five additional states have set voluntary renewable portfolio standards.



Energy Efficiency Resource Standards

Nineteen states have established a stand-alone energy efficiency resource standard or included a provision for energy efficiency within their renewable portfolio standard. Three additional states, New Jersey, Massachusetts and Rhode Island, are considering energy efficiency resource standards.



NOTE: Policies current as of May 8, 2009

SOURCE: Pew Charitable Trusts, 2009; based on analysis by Pew Center for Global Climate Change, Database of State Incentives for Renewables and Efficiency, and American Council for an Energy Efficient Economy.

Initiative (WCI). Florida has established its own individual state cap-and-trade regulatory program.

Renewable Portfolio Standards: Twenty-nine states and the District of Columbia have established renewable portfolio standards (RPS) since 1983, requiring electricity providers to supply a minimum percentage or amount of customer power from a renewable source of electricity. Florida, North Dakota, South Dakota, Utah and Virginia have set voluntary RPS goals. These renewable energy targets are expected to drive growth in already fast-growing areas of the clean energy economy. In Colorado, for example,

A STATE POLICY LEADER: TEXAS STATE REPRESENTATIVE WARREN CHISUM

Texas State Representative Warren Chisum (R-Pampa) is best known for his outspoken conservative positions on hot-button issues such as evolution and gay marriage. Chisum spent most of his non-legislative career working on drilling rigs and truck yards.

About a year ago, however, Chisum created the Texas Carbon Caucus, a bipartisan group of legislators who meet periodically to discuss issues related to carbon reduction and job creation and hear from leading thinkers from around the country. "The one and only rule is that we do not discuss global warming," Chisum said. "There will be no debate about whether it is caused by man or not as long as I'm in charge. We are only allowed to discuss what we are going to do about it."[85] Now that some of the potential solutions—namely wind energy—are proving not only viable but economically advantageous in Texas, legislators of all stripes are eager to talk about them. "Wind is a growing business and creates a lot of jobs," said Chisum. "The industry takes some of our smallest, most rural towns and makes them pretty active."[86] Today, Texas would rank sixth in the world for wind energy generation if it were a country. According to the American Wind Energy Association, it dwarfs all other states in wind capacity, and added more capacity than any other state in 2008.[87]

> Texas' wind industry would not be what it is today if the state had not put in place an aggressive renewable portfolio standard and other public policy measures 10 years ago, Chisum said.

Texas' wind farms did not sprout up overnight, as Chisum knows well from the 10 years he has spent on the House Environmental Regulations Committee. According to Chisum, before wind could take on a major role in powering the state, a strong natural gas infrastructure had to be in place to provide back-up power when necessary. And Texas' wind industry would not be what it is today if the state had not put in place an aggressive renewable portfolio standard and other public policy measures 10 years ago, he said.

Chisum would like to see Texas be more proactive as it looks toward its energy future. He sees solar power and carbon sequestration as the state's next big opportunities, and said he is sponsoring legislation this session that would create an underwater well for carbon sequestration off the coast of Houston. "We're preparing Texas," he said. "We're the largest carbon emitter, but we're going to be the first ones to take that carbon and put it where it needs to be."[88]

lawmakers recently doubled the standard after seeing the ease with which a lower target was met. "The standards created an economy based on renewable energy, creating demand for workers to build and maintain wind farms in areas that have suffered from a shrinking tax base," said state Representative Jack Pommer (D-Boulder). "Some rural areas are now growing from the economic influx."[89]

Energy Efficiency Resource Standards: Since 1999, 19 states have established a stand-alone Energy Efficiency Resource Standard (EERS) or included a provision for energy efficiency within the state's RPS.[90] EERS focus on natural gas and electric utilities, encouraging continually increasing energy savings over time. At this writing, three additional states—Massachusetts, New Jersey and Rhode Island—are actively considering similar policies. All state-based EERS include end-use energy savings improvements.[91]

California Vehicle Emissions Standards: Fourteen states—Arizona, Connecticut, Florida, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington—and the District of Columbia have adopted California's vehicle emissions standards, which require automakers to improve the fuel efficiency new cars and light trucks that resulting in a 30 percent reduction in carbon emissions by 2016. On May 19, 2009, President Obama announced that the Administration would establish the first-ever national limits on vehicle emissions that match California's while raising fleet-wide fuel efficiency standards to approximately 35.5 miles per gallon by 2016.

Eleven states—Arkansas, Alabama, Georgia, Kentucky, Louisiana, Mississippi, Nebraska, Oklahoma, South Carolina, Tennessee and West Virginia—offer financial incentives to drive their clean energy economies, but as of this writing do not participate in any regional initiatives and do not have either renewable portfolio or energy efficiency resource standards in place.

Federal Policies

The federal government has helped spur the development of the clean energy economy through policy reform and strategic investments. The Solid Waste Disposal Act, enacted in 1965, and the Resource Conservation and Recovery Act, enacted in 1976, fostered the development of the recycling, waste reduction and waste management industries, and the EPA's Energy Star and Water Sense certification and labeling initiatives long have helped encourage consumers to use products that save energy and water. And for almost two decades, the U.S. Department of Commerce has helped manufacturers improve efficiency, reduce waste and develop clean technologies and products.

In the past three years, federal policy makers have taken major steps to drive the clean energy economy forward. In 2007, President George W. Bush signed into law the first increase in fuel efficiency standards for cars and light trucks in more than 30 years, as part of the Energy Independence and Security Act.[92] This feat was unimaginable to many Congressional observers when just two years earlier, 67 members of the Senate opposed any increase in fuel efficiency. The legislation enacted in 2007 was supported by a majority of Republicans and Democrats, the United Auto Workers union, environmentalists and 89 percent of American voters. The Energy Independence and Security Act is expected to save 1.1 million barrels of oil a day, save consumers $25 billion at the pump and achieve reductions in greenhouse gas emissions equal to taking more than 28 million cars off the road.[93]

Enacted in February 2009, ARRA—the federal stimulus bill—includes an array of provisions to spur clean energy generation and energy efficiency businesses, jobs and investments. Among the almost $85 billion the package allocates to energy- and transportation-related spending, about $21 billion is dedicated to extending tax incentives for wind, solar and other renewable energy manufacturers. ARRA also provides more than $30 billion for direct spending on clean energy programs, including $11 billion to modernize the nation's electricity grid, $2 billion for advanced battery technology, more than $6 billion for state and local efforts to achieve energy efficiency, $5 billion for weatherization of low-income homes, $500 million for job training to help workers participate in the clean energy economy, and $300 million to purchase thousands of new, fuel-efficient vehicles for the federal fleet from American auto companies (Exhibit 17).

EXHIBIT 17: THE AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009
Energy- and transportation-related spending

The federal stimulus bill enacted in February 2009 includes an array of provisions to spur clean energy generation and energy efficiency businesses, jobs and investments. A total of $84.8 billion has been set aside for energy- and transportation- related spending. Amounts are in thousands.

AREA OF INVESTMENT	TOTAL INVESTMENT
Energy efficiency and conservation	$16,470,000
Improving the grid	$11,000,000
Energy research	$7,900,000
Clean energy generation	$6,000,000
Jobs training	$500,000
Vehicle spending	$2,600,000
Transportation spending	$18,400,000
Climate science research	$570,000
Tax credits for renewable energy and energy efficiency	$19,668,000
Tax credits for alternative fuel pumps	$54,000
Investment credits in energy generation and energy efficiency technologies	$1,600,000
Total	**$84,762,000**

SOURCE: Pew Center on Global Climate Change, Key Provisions: American Recovery and Reinvestment Act, March 2009 (updated April 16, 2009), http://www.pewclimate.org/docUploads/Pew-Summary-ARRA-Key-Provisions.pdf (accessed April 28, 2009).

Measuring Policy Effectiveness

How effective has each of these policy approaches been in generating jobs, businesses and investments in the clean energy economy? Given that most of the policy actions we examined were instituted in the last three years, there was not sufficient time between then and 2007, the year of the latest available jobs data, to analyze to what degree each has driven the clean energy economy to date. But our data do suggest a relationship. For instance, of the 18 states that have both renewable portfolio and energy efficiency standards in place, 11 states (61 percent) had more jobs in the clean energy economy than the national average. Similarly, in 12 of those 18 states, clean energy jobs made up a larger share of all jobs when compared to the U.S. average. Additionally, a number of venture capitalists, business leaders and policy makers we interviewed (see, e.g., profiles in this report of clean energy company Gamesa, venture capitalist Will Coleman and Texas State Representative Warren Chisum) cited state policies such as renewable portfolio standards as important factors in driving investments, attracting companies and growing new industries and jobs because they help create market demand for clean energy technologies, products and services.

With significant state and federal policy actions now in place or proposed—and our baseline count in hand—Pew will conduct follow-up research to assess how these measures are likely to affect the growth of U.S. jobs, businesses and investments in the clean energy economy moving forward.

Need for Comprehensive, Economy-wide Clean Energy Plan

Given America's need to create new and enduring jobs while conserving natural resources and reducing carbon emissions, federal leaders are deliberating additional measures to spur the clean energy economy.

President Obama has signaled his support for a federal market-based system to reduce greenhouse gas emissions by at least 80 percent by 2050; a national renewable portfolio standard that would require that 25 percent of the nation's energy supply be derived from renewable sources by 2025; and an energy efficiency resource standard that would require saving 15 percent of electricity and 10 percent of natural gas by 2020.[94] At this writing, the U.S. House of Representatives is considering the American Clean Energy and Security Act, a proposal that would limit overall greenhouse gas emissions and distribute tradable federal allowances for each ton of pollution emitted. The market-based program would apply to electric utilities, oil companies and other entities that produce more than 25,000 tons of carbon dioxide each year. The number of allowances would diminish over time, and the legislation would set a goal to reduce emissions to 83 percent below 2005 levels by 2050.[95] The bill would increase significantly the amount of energy derived from low- or zero-carbon sources, including renewables—meaning that businesses and jobs would be generated to develop clean energy sources to meet the demand.

Conclusion

Pew's first-of-its-kind analysis shows that the clean energy economy, still in its infancy, is emerging as a vital component of America's economic landscape. Across the country, jobs and businesses in the clean energy economy are being driven by consumer demand, venture capital infusions by private-sector investors eager to capitalize on new market opportunities, and policy reforms by federal and state lawmakers who want to spur economic growth while sustaining the environment.

Today, every state has a piece of the clean energy economy. But there will be winners and losers going forward. Policy makers who act quickly and effectively could see their states flourish, while others may lose opportunities for new jobs, businesses and investments. State leaders recognize this, and a growing number are pursuing measures such as financial incentives for clean energy generation and energy efficiency, renewable energy and energy efficiency standards, and laws to reduce vehicle emissions.

Through ARRA, the federal government has made an extraordinary investment that will give these and other efforts a significant boost. But to realize the clean energy economy's full potential, the nation needs a comprehensive, economy-wide energy plan. President Obama has expressed his support for a federal market-based system that would substantially reduce greenhouse gas emissions, and national standards that would help America draw more of its energy supply from clean, renewable sources and achieve greater energy efficiency. Those federal and state policies, together with continued private-sector support, will position the United States as a leader in the global clean energy economy.

APPENDIX A

Exhibit A1. U.S. Clean Energy Economy Segments

The clean energy economy has 16 segments (highlighted in green) that fall into five categories (highlighted in dark blue).

	Subsegment	Examples of Occupations
CLEAN ENERGY		
Energy Generation	**Energy consulting**	Electrical engineering technicians
	Energy management (software, services, devices)	Computer systems analysts
	Biomass (hydrogen, other, waste-to-energy)	Power plant operations technicians, process engineers
	Geothermal (geothermal drilling, generation, development, hardware)	Operating engineers and other construction equipment operators, drilling engineers (Geothermal)
	Hydro	Plumbers, power plant operators
	Marine and tidal	Mechanical engineering technicians
	Hydrogen	Mechanical engineering technicians, chemists
	Multiple	Solar and wind system installers
	Other (combined heat/power, hydrogen production, natural gas, on-site systems, waste heat, renewable energy providers)	Plumbers, electrical engineers
	Research and testing	Electrical engineers
	Solar (material feedstock supplier, PV: thin film, PV: polysilicon, concentrated PV, BIPV, solar thermal, solar installers and contractors, equipment sales and distribution)	Photonics engineers, solar power plant technicians
	Co-generation	Mechanical engineering technicians, boiler process engineers
	Accessory equipment and controls (solar, wind)	Electricians
	Other generation equipment	Mechanical engineering technicians
	Wind (consulting, water pumping systems, wind plant operators and developers, turbine and tower manufacturing, equipment sales and distribution)	Electricians, wind turbine service technicians
Energy Transmission	**Cable and equipment**	Electrical power-line installers and repairers
	Services (power monitoring and metering, power quality and testing)	Electricians, power distributors and dispatchers
	Transmission (sensors and controls, Smart Grid)	Electrical and electronic equipment assemblers
Energy Storage	**Advanced batteries** (Li-ion, NiMH, advanced PB-acid, charging and management, nickel zinc, other technologies, thin film, ultra capacitors, multiple)	Electrical and electronic engineering technicians
	Battery components and accessories	Electrical and electronic equipment assemblers, tool and die makers
	Fuel cells (methanol, PEM, solid oxide, systems integrators, zinc air)	Electro-mechanical technicians
	Hybrid systems (flywheels, heat storage, hydrogen storage)	Mechanical engineers
	Uninterruptible power supply	Electrical engineers
ENERGY EFFICIENCY		
Energy Efficiency	**Machinery** (geothermal heating and cooling, HVAC-R, boilers, water heating, efficient motors)	Heating and air conditioning mechanics and installers, thermal engineers
	Energy conservation consultant	Energy auditors
	Energy conservation software	Network systems and data communications analysts
	Energy conservation products	Electrical drafters, weatherization technicians/installers
	Glass	Press operators
	Lighting (CFL, solid state lighting, smart lighting systems, ballasts and controls)	Electricians; lighting design engineer; mixing and blending machine setters, operators, tenders (e.g. CFL/LED manufacturing)
	Meters and measuring devices (wireless)	Electrical engineering technicians
	Energy research	Electrical engineers
	Solar appliances and devices (solar cooker, solar heating, lighting)	Electrical and electronic equipment assemblers
ENVIRONMENTALLY FRIENDLY PRODUCTION		
Transportation	**Alternative fuels** (fueling infrastructure, biodiesel, ethanol, hydrogen)	Fuel system specialists
	Logistics (fleet tracking, traffic monitoring software)	Operations managers, logistic engineers
	Motor vehicles and equipment (electric bicycles and scooters, electric and hybrid vehicles, logistics/public transit vehicles, natural gas vehicles, diesel technology, vehicle components/engines, water transport, catalytic converters)	Electromechanical equipment assemblers, engine and chassis test engineers, engine and other machine assemblers
Manufacturing/ Industrial	**Advanced packaging** (containers, packing)	Materials scientists
	Industrial surface cleaning	Lab technicians
	Process management (construction/fabrication, process efficiency, resource utilization, toxin/waste minimization)	Mechanical engineering technicians, robotics technicians
	Monitoring and control (sensors, software, systems)	Systems analysts

APPENDIX A

Construction	**Building materials** (e.g., alternative cement)	Operating engineers and other construction equipment operators
	Design and construction (nonresidential architectural and engineering services, nonresidential building construction, residential architectural and engineering services, residential building construction, software)	Architect, roofer, construction and building inspectors (e.g. LEED Certification)
	Site management (deconstruction)	Environmental protection technicians
	Real estate and development	Construction and building inspectors
Agriculture	**Aquaculture** (farms, health and yield)	Environmental science technicians
	Land management (crop yield, precision agriculture, smart Irrigation, sustainable forestry)	Irrigation system installers, precision agriculture technicians
	Supplies and materials (alternative pest control, fertilizer)	Environmental science technicians
	Agribusiness consultant	Agricultural sustainability consultants
Energy Production	**Biofuel** (distillation and distribution)	Installers of industrial equipment, fuel distillers and distributors
	Coal gasification and pyrolysis	Geologists to assess basins for CO2 storage, chemists creating catalysts/ enzymes to remove CO2 from coal power generation, power plant operators that operate equipment that transports CO2
Materials	**Bio** (bioplastics, advanced processes, biodegradable products, catalysts)	Mixing and blending machine setters, operators and tenders
	Chemical (coatings, composites, polymer)	Coating, painting, and spraying machine setters, operators and tenders
	Nano (catalysts and additives, detectors and sensors, gels and coatings, lubricants and films, powders)	Laboratory technicians
	Other (adhesives, ceramics, electro textiles)	Laboratory technicians
CONSERVATION AND POLLUTION MITIGATION		
Air and Environment	**Emissions monitoring and control** (air quality, chemical sensors, carbon dioxide sensors, wireless sensors, sorbents, measurement and testing, software/systems)	Environmental science technicians
	Environmental consulting (environmental engineering, management and public relations, permitting, regulation and documentation, testing and certification, sustainable business/development consultant)	Environmental sustainability consultants, environmental compliance coordinators
	Environmental remediation (remediation equipment, ocean restoration)	Environmental engineering technicians
	Cleanup/safety (EHS and ERM, hazardous waste/toxins control, leak detection)	Hazardous materials removal workers, industrial hygienists
Recycling and Waste	**Consulting**	Materials scientists
	Recycling (Waste paper, paperboard and cloth materials, waste materials, metal, plastics and rubber scrap, bottles, automotive wrecking and recovery, oil and lubricants, electronic waste, recycling machinery manufacturing)	Refuse and recyclable material collectors, solids control technicians
	Waste treatment (environmental disposal, hazmat and plasma destruction)	Water and liquid waste treatment plant and system operators
Water and Wastewater	**Consulting**	Environmental science and protection technicians, including health; wetlands environmental biologists
	Pumps	Mechanical engineering technicians
	Research and testing	Geological science technicians
	Water conservation (recycling and management, metering and control)	Soil and water conservationists
	Water and wastewater treatment (contaminate detection, desalination, filtration and purification, plant and equipment, biological)	Chemical laboratory technicians, groundwater engineers
TRAINING AND SUPPORT		
Business Services	**Legal services**	Lawyers, paralegals and legal assistants
	Marketing/public relations	Public relations specialists
	Green firm business portal	Marketing analysts
	Staffing services	Human resources assistants
Finance/ Investment	**Project financing** (e.g., solar)	Financial accountants
	Project insurance	Credit risk analysts
	Venture capital/private equity	Investment bankers
	Emissions trading and offsets (carbon/emissions)	Statistical assistants, carbon credit traders
Research and Advocacy	**Alternative fuels** (hydrogen)	Biological technicians
	Geothermal	Geological sample test technicians
	Public education, job training	Vocational education teachers in postsecondary institutions, grant writers, environmental education specialists
	Solar	Heating and air conditioning mechanics and installers
	Wind	Mechanical engineering technicians
	Energy generation	Electrical engineering technicians
	Energy storage	Chemical laboratory technicians, fuel cell engineers
	Green building	Cost estimators
	Transportation	Mechanical engineering technicians

APPENDIX B

Methodology

This report counts jobs, companies, patents and venture capital investments that are part of the clean energy economy across all 50 states and the District of Columbia. We define the clean energy economy as one that generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources.

Pew researchers partnered with Collaborative Economics (CEI), a public policy research firm that has produced the *California Green Innovation Index* for the past two years. The *Index* comprises a series of reports that examine the intersection of economic growth and environmental policy in California; a central component of this work tracks the growth of businesses, jobs, investments and patents that make up the state's clean energy economy. The series is published by Next 10, a nonprofit research and advocacy group based in California.

For this study, Pew and CEI applied CEI's original methodology for assessing California to all 50 states and the District of Columbia.

Counting Jobs and Businesses

There are no perfect data sets with which to count jobs or businesses in the clean energy economy, and accurately counting this emerging economic activity is difficult. The U.S. Bureau of Labor Statistics (BLS) and the U.S. Census of Manufacturers are valuable resources for analyzing well-established industries, but these data do not classify jobs in the "clean energy economy" as a separate sector. As a result, Pew used micro-level establishment data to analyze the clean energy economy across the 50 states and the District of Columbia. For the purpose of this analysis, we count these businesses as those that produce or provide products and services that leverage renewable energy sources, conserve energy and natural resources, reduce pollution and recycle waste.

Public data on industries and employment are insufficient for examining this growing area of economic activity. Existing industry classification codes provide no straightforward industrial classification of jobs and businesses in the clean energy economy. Therefore, building on prior research of the clean energy economy, Pew's researchers constructed a database, using multiple sources and leveraging advanced Internet search technology.

As a first step in building the database, Pew's researchers identified companies receiving venture capital based on information provided by two membership organizations—Cleantech Group, LLC, and New Energy Finance—that track investment in the environment and clean energy technology. In addition, information about companies in the clean energy economy was gathered from industry associations and green business directories, press coverage, published articles, and databases of government incentive programs for renewable energy. As part of the process of identifying companies, we examined the Standard Industrial Classification (SIC) codes associated with each of these companies and mined the National Establishment Time Series database for other business units that could also be classified as a company in the clean energy economy.

National Establishment Time Series (NETS) Database. As mentioned above, we ran our list of companies through the NETS database published by Walls & Associates. NETS is a time series database based on Dun & Bradstreet (D&B) data, which are intended to cover the universe of business establishments—serving as a Yellow Pages of sorts for all known U.S. businesses. Our team analyzed the broad range of companies in the clean energy economy, allowing our researchers to identify similar and related companies that provide the clean energy economy's supply chain (e.g., manufacturers and suppliers of LED lighting), distribution networks (e.g., warehouses) and support activities (e.g., marketing professionals, lawyers) that deliver the products and services that respond to consumer demand. We limited our analysis to a set of core companies and jobs in the clean energy economy because it is difficult to separate the limited number of these jobs that reside in traditional companies (e.g., technicians working in utility companies to install energy monitoring devices in homes; a sustainability officer in Google, Inc., or another company whose job it is to help "green" the company's office space and operations). Because our analysis focused on identifying businesses in the clean energy economy and the jobs associated with these specific firms, Pew's count of these jobs is conservative.

Pew's research partner, CEI, developed the database, and the resulting business units fell into three categories: 1) businesses that fall into SIC codes that are completely part of the clean energy economy (e.g., energy conservation equipment); 2) businesses that fall into SIC codes that are partially green (e.g., plumbing contractors, electricians); and 3) businesses that are active in some area of the clean energy economy but have an SIC code that primarily represents a much broader scope of activities than clean energy (e.g., commercial nonphysical research).

The process resulted in two sets of eight-digit SIC codes: 1) SIC codes that were fully part of the clean energy economy (Exhibit B-1), and 2) SIC codes where a portion of the business units in that code were part of the clean energy economy. This second set of SIC codes required the additional process of identifying the companies in the clean energy economy through an Internet search platform using sets of keyword searches (see section on *QL2 Search Platform* below). The SIC codes for businesses units that are completely part of the clean energy economy make up about 60 percent of all companies and jobs in this emerging sector.

Pew relied on NETS to track trends in business growth from 1998 to 2007 across all 50 states and the District of Columbia. NETS includes an eight-digit SIC code, which was developed from the four-digit SIC code supported by the U.S. government prior to the six-digit North American Industry Classification System (NAICS)—the current coding system used by the U.S. government and BLS. The eight-digit SIC code allows far greater detail than NAICS to classify businesses and count the jobs associated with those companies.[96]

Pew researchers chose to use NETS based on its strengths relative to other datasets—providing the most detailed and comprehensive set of business unit information necessary for identifying business activities in the clean energy economy. D&B has established a sophisticated quality

EXHIBIT B-1: Establishments in the U.S. Clean Energy Economy

Standard Industrial Classification Codes that are fully part of the clean energy economy.

8-digit SIC	Description
1810103	Mats, preseeded: soil erosion, growing of
8510102	Reforestation services
13110201	Coal gasification
13110203	Coal pyrolysis
16290505	Waste water and sewage treatment plant construction
17110403	Solar energy contractor
17310202	Energy management controls
17310203	Environmental system control installation
17420204	Solar reflecting insulation film
17819901	Geothermal drilling
17969906	Pollution control equipment installation
17990210	Weather stripping
28210401	Carbohydrate plastics
28210407	Soybean plastics
28690104	Ethyl alcohol, ethanol
28739901	Fertilizers: natural (organic), except compost
28759901	Compost
28999913	Desalter kits, sea water
32110302	Insulating glass, sealed units
32310401	Insulating glass: made from purchased glass
34339904	Solar heaters and collectors
34430304	Economizers (boilers)
35110207	Wheels, water
35239906	Windmills for pumping water, agricultural
35590403	Desalination equipment
35599937	Recycling machinery
35890300	Sewage and water treatment equipment
35890301	Sewage treatment equipment
35890306	Water treatment equipment, industrial
36219909	Windmills, electric generating
36290102	Electrochemical generators (fuel cells)
36740305	Photovoltaic devices, solid state
36740306	Solar cells
36749901	Fuel cells, solid state
37110104	Cars, electric, assembly of
38220000	Environmental controls
38220206	Temperature controls, automatic

8-digit SIC	Description
38220300	Thermostats and other environmental sensors
38229900	Environmental controls, nec
38229905	Energy cutoff controls, residential or commercial types
38269907	Environmental testing equipment
38290218	Solarimeters
49119908	Hydro electric power generation
49520000	Sewerage systems
49539905	Recycling, waste materials
49539907	Sewage treatment facility
49590300	Toxic or hazardous waste cleanup
49590301	Oil spill cleanup
49590302	Environmental cleanup services
50399912	Soil erosion control fabrics
50740208	Heating equipment and panels, solar
50750103	Air pollution control equipment and supplies
50840706	Pollution control equipment, air (environmental)
50840707	Pollution control equipment, water (environmental)
50849914	Recycling machinery and equipment
50930000	Scrap and waste materials (all related codes)
52110300	Insulation and energy conservation products
52110301	Energy conservation products
52110303	Solar heating equipment
73890201	Air pollution measuring service
73899931	Meter readers, remote
76990304	Thermostat repair
81110208	Environmental law
86419903	Environmental protection organization
87110101	Pollution control engineering
87110403	Heating and ventilation engineering
87119906	Energy conservation engineering
87310302	Environmental research
87340300	Pollution testing
87349911	Water testing laboratory
87449904	Environmental remediation
87489904	Energy conservation consultant
87489905	Environmental consultant
89990703	Natural resource preservation service

SOURCE: Pew Charitable Trusts, 2009; analysis by Collaborative Economics, Inc.

control system and engages in extensive quality and consistency checks. Access to alternative data sources collected by federal and state government agencies that can be used to study some features of businesses and employment dynamics, such as BLS or the U.S. Census, is highly restricted because of confidentiality and requires a long and complex application and approval process. In contrast, NETS data are accessible and no confidentiality restrictions are imposed on users. And unlike public industry data, NETS covers companies with and without employees. NETS has been criticized in earlier research for both overstating total employment and for undercounting new businesses.[97] Its higher jobs numbers result from its better coverage of small businesses and the inclusion of small business owners in the count of employees; in fact, the NETS numbers are highly correlated with alternative data sources including the Quarterly Census of Employment and Wages, the Current Employment Statistics and the Size of Business data.[98] In other words, the NETS numbers describe the same trends as other data sources. And while NETS is sometimes slow to detect new businesses, it revises the establishment and jobs numbers in subsequent years' data, which corrects any previous undercount of new businesses.

QL2 Search Platform. To carry out a comprehensive Internet search of businesses in the clean energy economy across the 50 states, CEI designed the parameters of an Internet search infrastructure developed by QL2, a Seattle-based software engineering firm. The Internet search platform, created from a detailed set of search criteria and filters, allowed Pew to more comprehensively mine the Internet-based sources, link the results to NETS and verify the information collected. We used the QL2 platform to conduct an Internet search for company Web sites and to verify that these businesses were engaged in the clean energy economy, based on our definition. If a company did not have a Web site, it was not included in our final count of jobs and businesses because we were unable to systematically verify its clean energy economic activities.[99]

After the NETS and QL2 processes were complete, a team of analysts manually double checked the validity of the 50-state data.

Categories of Clean Energy Economy Jobs and Businesses. As part of the Internet and NETS-mining processes using the QL2 platform, business establishments were grouped in 16 segments:[100] energy generation; energy infrastructure; energy storage; energy efficiency; air and environment; recycling and waste; water and wastewater; agriculture; research and advocacy; business services; finance and investment; advanced materials; energy production; clean building; transportation; and manufacturing and industrial.

We then converted these 16 segments into five thematic categories for capturing and organizing clean energy economy businesses and jobs: (1) Clean Energy; (2) Energy Efficiency; (3) Environmentally Friendly Production; (4) Conservation and Pollution Mitigation; and (5) Training and Support.

While specific jobs and businesses will change—for example, a company that supplies hybrid diesel engines for buses may supply a fundamentally different type of engine a decade from now—these five sectors of the clean energy economy should remain constant.

APPENDIX B

Tracking Investments and Patent Registrations

Venture capital investments and patent registrations reveal where innovation in the clean energy economy is taking place and where regional specializations are emerging. Venture capital investment data were provided by the Cleantech Group™, LLC, and tracked investments by industry segment.[101] Working with 1790 Analytics, a research firm that specializes in intellectual property evaluation, Pew's researchers developed search criteria for tracking patent registrations in clean technology over time. 1790 Analytics processes U.S. Patent and Trade Office (USPTO) data on a weekly basis. Using terms related to clean technologies, 1790 Analytics provided the data for new patent registrations related to solar energy, wind energy, batteries, fuel cells and hybrid systems. Both patent and venture capital data were collected from 1999 to 2008.

State Policies

Both the report and our supplemental fact sheets for each of the 50 states and the District of Columbia highlight the strengths of each state's clean energy economy—jobs, companies and investments. Pew's researchers also examined the public policies likely to drive future clean energy economy growth in each state. We looked at states' provision of financial incentives, participation in regional initiatives, implementation of renewable portfolio standards and energy efficiency resource standards, and adoption of California's vehicle emissions standards.

Pew's researchers obtained information about state renewable energy and energy efficiency financial incentives such as tax credits and deductions, bonds, grants, loans and rebate programs from the Database of State Incentives for Renewables and Efficiency, a project sponsored by the North Carolina Solar Center and the Interstate Renewable Energy Council and funded by the U.S. Department of Energy.[102]

Pew's researchers tracked state participation in the three active regional initiatives—(1) Regional Greenhouse Gas Initiative (RGGI); (2) Midwestern Greenhouse Gas Reduction Accord (MGGRA); and (3) Western Climate Initiative (WCI)—by consulting the Pew Center on Global Climate Change's Web site (http://www.pewclimate.org/what_s_being_done/ in_the_states/regional_initiatives.cfm). Researchers then confirmed each state's participation by reviewing state governors' press releases from each initiative's Web site: (1) RGGI - http://www.rggi.org; (2) MGGRA - http://www.midwesternaccord.org/; and (3) WCI - http://www.westernclimateinitiative.org/. We also noted which states had signed on as "observers" to the regional initiatives.

To draw attention to states that had mandatory renewable portfolio standards (RPS) in place, we consulted the Pew Center on Global Climate Change's Web site (http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm). We verified the states' RPS policies using the U.S. Environmental Protection Agency's (EPA) Web site (http://www.epa.gov/solar/energy-programs/state-and-local/supply_actions.html#rps). The EPA credits 34 states with RPS policies, including states with voluntary standards or RPS goals; Pew's analysis does not count those latter states. To identify states that have or are considering adopting energy efficiency resource standards, we consulted a March 2009 report by the American Council for an Energy-Efficient Economy (http://aceee.org/pubs/e091.pdf?CFID=3657226&CFTOKEN=86100118).

Other Studies

Several organizations recently have published reports about the growth in "green jobs" and the "green economy." Among them (in order of publication date):

- Center for American Progress and the Political Economic Research Institute at the University of Massachusetts Amherst (CAP/PERI), *Job Opportunities for the Green Economy: A State-by-State Picture of Occupations that Gain from Green Investments* (June 2008).
- Center for American Progress and the Political Economic Research Institute at the University of Massachusetts Amherst (CAP/PERI), *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy* (September 2008).
- U.S. Conference of Mayors and Global Insight, *Current and Potential Green Jobs in the U.S. Economy* (October 2008).
- Gary Gereffi, Kristen Dubay and Marcy Lowe, *Manufacturing Climate Solutions: Carbon-Reducing Technologies and U.S. Jobs*, Center on Globalization, Governance & Competitiveness, Duke University (November 2008).

Three principal differences distinguish Pew's report from these and other, similar efforts. First, previous efforts looked only at jobs and either provided numbers for a specific industry, such as solar, or estimates generated by statistical modeling; our report analyzes jobs at the business-unit level, businesses, venture capital investments and patent registrations over time. By examining different aspects of the clean energy economy—not just jobs—Pew highlights investments being made today that will drive growth in the future. Second, using jobs numbers based on NETS data and a sophisticated software platform that enabled Pew to search and verify the activities of firms, we count actual jobs and businesses in the clean energy economy, rather than relying on estimates. The businesses included in the database are based on evidence of actual business activities. Finally, previous efforts focused on energy generation and efficiency; we also counted jobs and businesses that enable the United States to manage water and other finite natural resources more effectively, to mitigate emissions of greenhouse gases and other pollutants that result from the continued use of fossil fuels, and to recycle materials and resources to help businesses reduce their carbon footprint.

Exhibit C1. Businesses in the U.S. Clean Energy Economy, 1998-2007

State	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Alabama	765	764	768	789	819	815	806	782	804	799
Alaska	327	331	333	345	367	367	360	359	350	350
Arizona	1,009	1,027	1,039	1,047	1,093	1,099	1,088	1,122	1,139	1,123
Arkansas	434	424	416	420	440	435	444	440	445	448
California	8,906	8,971	8,899	9,248	9,848	10,066	10,213	10,195	10,348	10,209
Colorado	1,463	1,468	1,505	1,564	1,676	1,706	1,699	1,682	1,760	1,778
Connecticut	799	804	780	806	801	818	825	829	864	857
Delaware	204	205	207	213	220	213	207	205	213	211
District of Columbia	243	244	253	263	280	274	286	291	295	280
Florida	3,121	3,131	3,121	3,214	3,582	3,643	3,663	3,664	3,801	3,831
Georgia	1,483	1,533	1,536	1,576	1,690	1,702	1,688	1,679	1,824	1,827
Hawaii	288	294	291	309	328	333	334	333	355	356
Idaho	365	376	387	410	436	434	436	437	434	428
Illinois	2,111	2,043	2,008	2,038	2,125	2,133	2,134	2,131	2,170	2,176
Indiana	1,135	1,107	1,101	1,144	1,226	1,231	1,225	1,214	1,259	1,268
Iowa	637	634	641	670	730	716	708	699	736	729
Kansas	570	563	570	577	588	595	581	564	596	591
Kentucky	697	679	675	701	722	724	718	722	750	778
Louisiana	949	947	933	949	1,007	993	1,003	975	994	995
Maine	691	710	703	703	721	733	728	736	743	725
Maryland	1,044	1,042	1,028	1,040	1,134	1,104	1,122	1,134	1,162	1,145
Massachusetts	1,819	1,773	1,753	1,777	1,836	1,852	1,842	1,903	1,921	1,912
Michigan	1,858	1,808	1,788	1,811	1,906	1,890	1,882	1,897	1,952	1,932
Minnesota	1,120	1,106	1,116	1,107	1,189	1,235	1,247	1,205	1,208	1,206
Mississippi	387	387	394	395	434	439	437	449	447	454
Missouri	1,026	1,020	987	986	1,036	1,023	1,022	1,028	1,057	1,062
Montana	311	316	328	355	365	380	382	405	409	408
Nebraska	312	312	317	322	332	359	348	353	359	368
Nevada	345	347	350	384	465	480	489	502	521	511
New Hampshire	414	418	414	416	456	470	470	453	462	465
New Jersey	2,157	2,127	2,078	2,093	2,164	2,121	2,083	2,045	2,026	2,031
New Mexico	502	525	515	544	557	557	559	570	581	577
New York	3,258	3,195	3,150	3,186	3,473	3,481	3,440	3,320	3,304	3,323
North Carolina	1,449	1,493	1,518	1,563	1,652	1,641	1,665	1,705	1,794	1,783
North Dakota	124	122	123	132	142	144	148	141	142	137
Ohio	2,388	2,342	2,344	2,414	2,503	2,512	2,469	2,476	2,514	2,513
Oklahoma	726	724	703	694	724	712	726	715	712	693
Oregon	1,323	1,356	1,383	1,410	1,508	1,531	1,553	1,569	1,608	1,613
Pennsylvania	2,893	2,893	2,879	2,890	3,223	3,222	3,135	2,929	2,939	2,934
Rhode Island	234	234	232	242	252	256	250	249	243	237
South Carolina	775	789	785	806	849	870	874	872	889	884
South Dakota	122	121	129	131	144	148	155	157	164	169
Tennessee	955	970	974	1,001	1,034	1,026	1,039	1,062	1,080	1,090
Texas	4,247	4,309	4,346	4,473	4,801	4,802	4,806	4,773	4,819	4,802
Utah	473	478	485	509	587	588	589	562	575	579
Vermont	279	286	281	295	319	319	319	319	317	311
Virginia	1,237	1,251	1,263	1,323	1,413	1,436	1,457	1,451	1,472	1,446
Washington	1,920	2,032	1,992	2,029	2,102	2,082	2,062	2,012	2,022	2,008
West Virginia	348	338	341	350	371	360	352	327	325	332
Wisconsin	1,249	1,245	1,225	1,248	1,291	1,272	1,291	1,299	1,297	1,294
Wyoming	197	212	212	228	251	240	237	234	234	225
U.S. Total	61,689	61,826	61,599	63,140	67,212	67,582	67,596	67,175	68,435	68,203

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

Exhibit D1. Jobs in the U.S. Clean Energy Economy, 1998-2007

State	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Alabama	7,678	7,388	7,640	7,825	8,325	8,089	7,678	7,667	7,678	7,849
Alaska	1,956	1,947	1,930	2,040	2,270	2,310	2,174	2,048	2,043	2,140
Arizona	9,547	9,458	10,050	10,455	10,686	10,841	11,214	11,549	11,463	11,578
Arkansas	4,266	4,353	4,130	4,461	4,491	4,043	4,116	4,040	4,326	4,597
California	116,441	117,610	123,475	125,221	128,832	122,959	120,153	117,114	122,903	125,390
Colorado	14,393	15,804	16,595	17,218	16,903	16,736	15,711	15,547	16,022	17,008
Connecticut	9,484	9,677	8,814	10,715	11,287	10,976	11,248	11,203	10,052	10,147
Delaware	2,424	2,548	2,779	2,775	2,917	2,904	2,314	2,638	2,395	2,368
District of Columbia	4,483	4,306	4,594	5,289	5,608	5,599	5,140	5,254	5,426	5,325
Florida	28,845	29,138	29,254	28,467	30,739	30,292	30,568	29,437	30,527	31,122
Georgia	14,645	14,799	14,623	14,689	15,786	16,207	16,121	16,513	16,243	16,222
Hawaii	1,903	2,064	2,175	2,256	2,396	2,455	2,281	2,303	2,710	2,732
Idaho	1,998	2,252	2,648	2,803	3,447	4,537	4,462	4,141	4,146	4,517
Illinois	29,136	28,773	27,278	27,474	27,662	27,497	27,420	26,820	27,025	28,395
Indiana	14,666	15,467	16,033	16,521	16,823	16,238	16,200	16,338	16,840	17,298
Iowa	6,106	6,272	6,600	6,959	7,157	7,053	6,942	6,999	7,553	7,702
Kansas	5,308	5,262	5,483	6,055	6,444	6,572	6,631	6,993	7,444	8,017
Kentucky	8,465	8,577	8,777	9,187	9,049	9,224	9,330	8,952	9,123	9,308
Louisiana	8,908	9,600	9,762	10,272	10,512	10,491	10,130	10,271	9,984	10,641
Maine	4,888	5,010	5,005	5,006	5,364	5,719	5,827	5,754	5,805	6,000
Maryland	13,224	13,465	13,226	13,240	14,741	13,886	12,632	12,932	12,445	12,908
Massachusetts	25,580	24,604	23,842	24,057	24,742	25,220	24,444	24,630	26,381	26,678
Michigan	20,489	20,385	21,546	23,064	23,328	22,068	21,618	21,706	22,185	22,674
Minnesota	17,868	18,037	18,696	18,303	20,095	20,660	20,694	18,947	18,764	19,994
Mississippi	2,564	2,591	2,618	2,848	3,028	2,911	2,926	3,115	3,060	3,200
Missouri	11,116	12,494	12,472	12,959	13,132	12,360	12,240	11,501	11,525	11,714
Montana	2,151	2,158	2,166	2,255	2,173	2,083	1,891	1,899	2,086	2,155
Nebraska	2,537	2,639	2,768	2,758	3,127	3,347	3,262	5,403	5,391	5,292
Nevada	2,826	2,899	2,582	2,667	3,056	3,112	2,933	2,961	3,347	3,641
New Hampshire	3,950	3,882	3,478	3,368	3,887	3,850	3,741	3,959	4,045	4,029
New Jersey	28,097	27,555	27,412	27,917	28,658	27,283	25,917	25,146	25,048	25,397
New Mexico	3,208	3,358	3,443	3,896	4,165	4,174	4,238	4,247	4,254	4,815
New York	35,028	35,849	37,606	37,861	39,296	37,774	36,774	34,044	34,016	34,363
North Carolina	14,742	14,771	15,832	16,012	16,176	16,501	16,305	17,026	16,929	16,997
North Dakota	1,613	1,814	1,803	1,821	1,875	2,009	1,955	1,909	2,099	2,112
Ohio	32,874	32,902	33,413	35,882	37,294	34,788	34,349	34,705	35,513	35,267
Oklahoma	5,119	5,499	6,238	6,033	6,039	6,036	6,030	5,608	5,633	5,465
Oregon	12,833	13,552	13,910	14,333	14,931	15,678	16,386	19,191	19,010	19,340
Pennsylvania	41,336	46,741	47,767	44,666	46,846	46,018	44,594	39,013	39,047	38,763
Rhode Island	2,311	2,476	2,437	2,879	2,982	2,822	2,800	2,529	2,401	2,328
South Carolina	8,264	8,647	8,777	9,807	10,339	10,655	11,323	11,092	11,291	11,255
South Dakota	846	779	826	913	1,069	1,087	1,200	1,423	1,471	1,636
Tennessee	13,123	15,314	15,704	17,690	16,399	16,546	16,491	16,409	16,594	15,507
Texas	48,199	51,775	51,024	52,063	55,143	51,942	50,825	52,110	55,470	55,646
Utah	5,938	5,100	5,233	5,290	5,047	4,824	4,871	5,170	5,207	5,199
Vermont	1,875	1,854	1,733	1,899	2,029	2,119	2,073	2,133	2,166	2,161
Virginia	15,947	16,256	16,366	16,531	16,656	16,733	16,946	16,639	16,906	16,907
Washington	16,928	18,215	18,405	19,201	19,620	16,990	16,935	16,264	16,384	17,013
West Virginia	3,197	3,064	3,244	3,201	3,432	3,251	3,336	3,086	3,065	3,065
Wisconsin	15,921	16,172	15,881	16,630	16,399	16,302	16,377	15,691	15,929	15,089
Wyoming	907	990	1,072	1,129	1,201	1,202	1,199	1,222	1,351	1,419
U.S. Total	706,151	726,142	739,165	756,861	783,603	764,973	752,965	743,291	758,721	770,385

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

APPENDIX E

Exhibit E1. U.S. Clean Energy Patents, 1999-2008

State	Total Patents, 1999-2008
Alabama	26
Alaska	1
Arizona	178
Arkansas	8
California	1,401
Colorado	161
Connecticut	404
Delaware	43
District of Columbia	9
Florida	236
Georgia	256
Hawaii	16
Idaho	73
Illinois	297
Indiana	174
Iowa	46
Kansas	15
Kentucky	17
Louisiana	22
Maine	8
Maryland	134
Massachusetts	384
Michigan	749
Minnesota	218
Mississippi	3
Missouri	25
Montana	5
Nebraska	15
Nevada	71
New Hampshire	74
New Jersey	248
New Mexico	95
New York	909
North Carolina	179
North Dakota	5
Ohio	309
Oklahoma	36
Oregon	163
Pennsylvania	241
Rhode Island	51
South Carolina	49
South Dakota	4
Tennessee	47
Texas	414
Utah	47
Vermont	12
Virginia	68
Washington	195
West Virginia	14
Wisconsin	214
Wyoming	15
U.S. Total	8,384

SOURCE: Pew Charitable Trusts, 2009, based on data from 1790 Analytics; analysis by Pew Center on the States and Collaborative Economics.

Exhibit E2. U.S. Clean Energy Venture Capital, 2006-2008

State	Venture Capital, 2006-2008
Alabama	$0
Alaska	$0
Arizona	$31,105,879
Arkansas	$22,844,701
California	$6,580,426,908
Colorado	$622,400,734
Connecticut	$30,050,286
Delaware	$3,342,057
District of Columbia	$89,877,117
Florida	$116,980,006
Georgia	$179,685,738
Hawaii	$12,303,914
Idaho	$27,890,265
Illinois	$108,519,023
Indiana	$26,000,000
Iowa	$149,237,274
Kansas	$13,274,882
Kentucky	$0
Louisiana	$0
Maine	$0
Maryland	$323,995,916
Massachusetts	$1,278,461,918
Michigan	$55,099,376
Minnesota	$49,937,944
Mississippi	$30,383,955
Missouri	$24,479,634
Montana	$0
Nebraska	$0
Nevada	$19,804,386
New Hampshire	$66,917,018
New Jersey	$282,567,651
New Mexico	$147,912,504
New York	$209,590,500
North Carolina	$82,570,734
North Dakota	$0
Ohio	$74,224,203
Oklahoma	$5,191,978
Oregon	$70,001,922
Pennsylvania	$232,897,084
Rhode Island	$22,844,701
South Carolina	$0
South Dakota	$0
Tennessee	$16,328,927
Texas	$716,894,200
Utah	$26,957,250
Vermont	$53,746,890
Virginia	$70,828,261
Washington	$635,108,739
West Virginia	$5,740,751
Wisconsin	$46,742,521
Wyoming	$6,941,813
U.S. Total	$12,570,109,562

SOURCE: Pew Charitable Trusts, 2009, based on data from The Cleantech Group™ LLC; analysis by Pew Center on the States and Collaborative Economics.

APPENDIX F

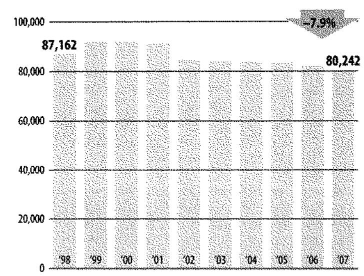
Nuclear Energy in the United States

In 2007, there were 574 nuclear energy establishments in the United States accounting for a total of 80,242 jobs, including jobs in power generation, plant and equipment production, public administration and nuclear consulting.

During the past 10 years, the nuclear energy industry has lost jobs at an average annual rate of 0.9 percent. In 2007 jobs in the nuclear energy industry reached a 10-year low after peaking in 1999 with just more than 92,000 total nuclear energy jobs.

These jobs and establishments are located in 46 states and the District of Columbia. Alaska, Hawaii, Montana and North Dakota had no jobs in the nuclear energy industry as of 2007. Delaware, Indiana, Kentucky, Maine, Oklahoma, Rhode Island, South Dakota, Utah and West Virginia all had fewer than 100 nuclear energy jobs as of 2007. A majority of the jobs in nuclear energy are concentrated in a small number of states. California, Illinois, New York, North Carolina, Maryland, Massachusetts, Pennsylvania, South Carolina, Texas and Virginia are the 10 states with the most jobs in nuclear energy.

U.S. NUCLEAR ENERGY JOBS 1998-2007



SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics.

U.S. NUCLEAR ENERGY JOBS

States with the Most Nuclear Energy Jobs, 2007

Illinois	7,605
New York	6,223
Texas	5,839
California	4,608
North Carolina	4,234
Virginia	4,197
Maryland	4,058
Pennsylvania	4,025
South Carolina	3,749
Massachusetts	3,443

SOURCE: Pew Charitable Trusts, 2009, based on the National Establishment Time Series Database; analysis by Pew Center on the States and Collaborative Economics

Endnotes

1 U.S. Bureau of Labor Statistics, Current Employment Statistics, http://www.bls.gov/ces/ (accessed April 16, 2009).

2 U.S. Bureau of Labor Statistics, Employment Situation Summary, April 3, 2009, http://www.bls.gov/news.release/empsit.nr0.htm (accessed May 2, 2009).

3 Pew Research Center Poll, May 8, 2008, http://pewresearch.org/pubs/828/global-warming (accessed April 15, 2009).

4 National Governors Association, *Securing a Clean Energy Future: A Call to Action*, December 2007, p. 1 http://www.nga.org/Files/pdf/0712SCEFCALLTOACTION.PDF (accessed May 3, 2009).

5 Pew Center on Global Climate Change, "Renewable Portfolio Standards (RPS)," http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm (accessed May 19, 2009). Database of State Incentives for Renewables and Efficiency, "District of Columbia," http://dsire.org/incentives/incentive.cfm?incentiveCode=DC04&re=1&ee=1 (accessed May 19, 2009).

6 American Council for an Energy-Efficient Economy (ACEEE), *Laying the Foundation for Implementing a Federal Energy Efficiency Resource Standard*, March 2009, http://aceee.org/pubs/e091.pdf?CFID=3657226&CFTOKEN=86100118 (accessed May 19, 2009).

7 Pew Center on Global Climate Change, Key Provisions: American Recovery and Reinvestment Act, March 2009 (updated April 16, 2009), http://www.pewclimate.org/docUploads/Pew-Summary-ARRA-Key-Provisions.pdf (accessed April 28, 2009).

8 Michigan Department of Energy, Labor and Economic Growth, "Michigan Fast Facts," http://www.milmi.org/ (accessed April 28, 2009).

9 Pew interview with Skip Pruss, director of the Michigan Department of Energy, Labor and Economic Growth, April 3, 2009.

10 Ibid.

11 *See* Center for American Progress and the Political Economic Research Institute at the University of Massachusetts Amherst (CAP/PERI), *Job Opportunities for the Green Economy: A State-by-State Picture of Occupations that Gain from Green Investments* (June 2008) and *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy* (September 2008). *See also* U.S. Conference of Mayors (USCM) and Global Insight, *Current and Potential Green Jobs in the U.S. Economy* (October 2008).

12 Despite the popularity of the term "green economy," there has been no consensus to date about what it actually means. No government data source counts green businesses or jobs as such, and as a result, the "green economy" is not classified as an industry. The "green" label has become so ubiquitous that it has lost, rather than gained, meaning, focus and value. A growing number of policy, business and opinion leaders prefer the term "clean energy economy," which reflects the critical focus on developing renewable energy sources that expand market opportunities, strengthen America's fiscal health, reduce our nation's dependence on traditional fossil fuels, and mitigate pollution from global warming.

13 *Low-impact hydropower.* Low-impact hydropower is hydroelectric power generated with fewer environmental impacts; it must meet criteria such as minimally obstructing river flows, maintaining water quality, easing fish passage, and protecting the watershed. Such hydropower facilities often operate using the natural flow of rivers, rather than storing water in a reservoir and releasing it to create greater currents. *See* U.S. Department of Energy, Energy Efficiency and Renewable Energy, Federal Energy Management Program; EPA Green Power Partnership; World Resources Institute, Sustainable Enterprise Program; and Center for Resource Solutions, Green-e Renewable Energy Certification Program, *Guide to Purchasing Green Power: Renewable Electricity, Renewable Energy Certificates, and On-Site Renewable Generation*, September 2004, p. 35.

Hydrogen fuel cells. As an energy carrier, hydrogen can be used to store and deliver clean and renewable energy. Hydrogen can be produced from a variety of domestic reserves including natural gas, coal, wind and solar power. Once extracted, hydrogen gas is combined with oxygen in fuel cells to create energy. Hydrogen power fuel cells can meet a spectrum of energy demands, from small-scale portable energy used to power private transportation to large-scale baseload energy generators. *See* U.S. Department of Energy Hydrogen Program, http://www.energy.gov/energysources/hydrogen.htm (accessed April 29, 2009).

Marine and tidal. Marine and tidal, also known as hydrokinetic, power sources seek to capture energy from waves, tides, ocean currents and the natural flow of water in rivers as well as marine thermal gradients, without building new dams or diversions. Emerging technologies seek to capture and convert these sources of kinetic energy into renewable power. *See* U.S. Department of Energy, Energy Efficiency and Renewable Energy Program: Wind and Hydropower Technologies, http://www1.eere.energy.gov/windandhydro/hydro_about.html (accessed April 29, 2009).

Geothermal. Geothermal energy harnesses the heat trapped below the earth's immediate surface. Geothermal heat pumps can use shallow ground energy (less than 10 feet below the earth's surface) to direct heat and cool office buildings and homes. Large-scale geothermal plants can harness the steam released even further below the surface to drive turbines and generate electric power. *See* U.S. Department of Energy, Energy Efficiency and Renewable Energy Program: Geothermal Technologies Program, http://www1.eere.energy.gov/geothermal/geothermal_basics.html (accessed April 29, 2009).

14 *Small-scale biopower.* Our definition and data capture only jobs and services that enable small-scale biopower energy generation activities such as wood combustion in power plants and the burning of biomethane for energy. The jobs we capture include those that make it possible for dairy farmers to offset their energy needs by using biomethane from manure, for paper plants to burn their scraps and reduce energy demands, and for plants such as the BMW factory in Spartanburg, South Carolina, to meet a percentage of its energy demands by capturing and burning biomethane released at a nearby landfill (*see* http://www.bmwusa.com/Standard/Content/Uniquely/BMWInTheCommunity/CommunityandEnvironment.aspx).

15 *See* Steve Olson and Robert W. Fri, eds., "National Academies Summit on America's Energy Future," The National Academies Press, Washington, D.C., 2008, pp. 44-48. Also, nuclear power plants are capital intensive, much like coal-fired plants. Cost estimates for new nuclear plants range from $9 billion to $13 billion; *see* Peter Behr, "A key energy industry nervously awaits its 'rebirth'," *The New York Times*, April 27, 2009, http://www.nytimes.com/cwire/ 2009/04/27/ 27climatewire-a-key-energy-industry-nervously-awaits-its-r-10677.html?pagewanted=1 (accessed April 29, 2009) and Terry Macalister, "Westinghouse Wins First U.S. Nuclear Deal in 30 Years," *The Guardian*, April 10, 2008, http://www.guardian.co.uk/world/2008/apr/10/nuclear.nuclearpower (accessed April 29, 2009). In addition, the technology to reprocess spent fuel is at least 40 to 50 years away and international proliferation resistant measures/agreements are not in place for nuclear power to be rapidly expandable; thus, it remains a highly centralized form of energy production and delivery can be problematic if plants go offline.

16 Research suggests that biofuel production can have a positive net energy balance, particularly if the newest and most efficient production facilities are utilized. But biomass used to produce these fuels face sustainability challenges over where the biomass will come from (e.g., food for fuel and other land use decisions). *See* Adam J. Liska, Haishun S. Yang, Virgil R. Bremer, Terry J. Klopfenstein, Daniel T. Walters, Galen E. Erickson and Kenneth G. Cassman, "Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol," *Journal of Industrial Ecology* (13) 1, pp. 58-74; Alexander E. Farrell, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare and Daniel M. Kammen, "Ethanol Can Contribute to Energy and Environmental Goals," *Science*, January 27, 2006 (311), pp. 506-508. However, other research suggests that biomass can be generated sustainably, such as from agricultural residue and waste products, including forestry waste, storm and pest-damaged trees, forest thinning for fire risk reduction, municipal waste or food industry waste, or by using perennial crops on degraded/abandoned cropland or pasture that is no longer suitable for other agricultural purposes. *See* Robert D. Perlack, Lynn L. Wright, Anthony F. Turhollow, Robin L. Graham, Bryce J. Stokes and Donald C. Erbach, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, U.S. Department of Energy and U.S. Department of Agriculture, Washington, D.C., 2005; J. Elliot Campbell, David B. Lobell, Robert C. Genova and Christopher B. Field, "The Global Potential of Bioenergy on Abandoned Agriculture Lands," *Environment Science Technology* (42), 2008, pp. 5791–5794.

17 Pew's Environmentally Friendly Production category excludes agricultural jobs and focuses only on infrastructure for biofuel production—distillation and distribution centers. Venture capital firms are investing heavily in second generation biofuels, technologies that seek to use more sustainable feedstocks, such as switchgrass—and distillation and distribution centers are an important, job-generating part of how we might develop biofuels that are more sustainable than corn-based ethanol moving forward (*see* Cleantech Group™ LLC, *Cleantech Investment Monitor 2008 Annual Review and 4Q08 Quarterly*, 2009). In addition, in the transportation portion of the Environmentally Friendly Production category, we capture jobs that produce and supply alternative products and services to mass transit operators, including compressed natural gas engines and monitoring systems that allow for more effective deployment of public transit. Pew does not include bus drivers, mechanics or administrators who work for public transit agencies.

18 Board on Energy and Environmental Systems, National Research Council and Curt Suplee, "What You Need to Know About Energy," Washington, D.C., The National Academies Press, 2008, p. 14.

19 U.S. Environmental Protection Agency, "2009 U.S. Greenhouse Gas Inventory Report: Inventory of U.S Greenhouse Gas Emissions and Sinks 1990-2007," April 2009, http://www.epa.gov/climatechange/ emissions/usinventoryreport.html (accessed April 16, 2009).

20 Rather than being burnt directly, during gasification and pyrolysis, coal is exposed to steam and oxygen under high temperatures and pressures. This heat and pressure breaks down coal into its basic chemical parts—in a gaseous form in gasification and in a liquid form in pyrolysis. Once broken down into these components, the noxious outputs of coal burning (carbon dioxide, sulfur and nitrogen) can be better trapped and the resulting gases and liquids can be used to make cleaner energy. Information from the U.S. Department of Energy, "Clean Coal and Natural Gas Power Systems," http://fossil.energy.gov/programs/powersystems/gasification/, last updated December 8, 2008.

21 Olson and Fri, eds., "National Academies Summit on America's Energy Future," Washington, D.C., The National Academies Press, 2008, p. 80.

22 William Choate, "U.S. Energy Requirements for Aluminum Production: Historical Perspectives, Theoretical Limits, and New Opportunities," in John A.S. Green (ed.), *Aluminum Recycling and Processing for Energy Conservation and Sustainability*, Materials Park, OH: ASM International, 2007, p. 204.

23 Joel Makower, Ron Pernick and Clint Wilder, "Clean Energy Trends 2009," *Clean Edge*, March 2009, http://www.cleanedge.com/ reports/reports-trends2009.php (accessed March 30, 2009).

24 Jeffrey T. Macher and David C. Mowery, eds., Committee on the Competitiveness and Workforce Needs of U.S. Industry, in "Innovation in Global Industries: U.S. Firms Competing in a New World," Washington, D.C., The National Academies Press, 2008, http://books.nap.edu/openbook.php? record_id=12112&page=231 (accessed May 2, 2009).

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25 Biotechnology Industry Organization, "Biotechnology Industry Facts," 2008, http://www.bio.org/speeches/pubs/er/statistics.asp (accessed May 2, 2009).

26 Ernst & Young LLP, *Beyond Borders: Global Biotechnology Report 2008*, 2008, http://www.ey.com/Publication/vwLUAssets/Industry_Biotechnology_Beyond_Borders_2008/$file/Biotechnology_Beyond_Borders_2008.pdf (accessed April 28, 2009).

27 U.S. Bureau of Labor Statistics, Current Employment Statistics, http://www.bls.gov/ces/ (accessed April 16, 2009).

28 U.S. Bureau of Labor Statistics (BLS), Occupational Employment Survey, May 2007. Pew's researchers matched NETS data with the BLS occupational data to estimate the earnings for jobs in the clean energy economy. Annual wages have been calculated by multiplying the hourly mean wage by a "year-round, full-time" hours figure of 2,080 hours; for those occupations where there is not an hourly mean wage published, the annual wage has been directly calculated from the reported survey data.

29 Kathy Krepcio, executive director of the John J. Heldrich Center for Workforce Development at Rutgers University, testimony before the U.S. House of Representatives Committee on Education and Labor, March 31, 2009, http://edlabor.house.gov/documents/111/pdf/testimony/20090331KathyKrepcioTestimony.pdf (accessed May 2, 2009).

30 Hemlock Semiconductor highlights the conservative nature of Pew's count of businesses and jobs in the clean energy economy. Although Hemlock is one of the country's largest producers of polysilicon used to produce solar photovoltaic devices, a large portion of Hemlock's polysilicon business is rooted in the semiconductor industry, which we could not classify as a part of the clean energy economy. Because these two areas of polysilicon activity are not divided into two separate business units, we were not able to isolate the jobs at Hemlock related to the production of polysilicon for solar photovoltaics. Unless we were able to classify an entire establishment or isolate one of its business units as part of the clean energy economy, it was not included in our analysis. As a result, Hemlock Semiconductor was not included in our establishment and jobs count.

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34 Pew interview with Ron Gonen, co-founder and CEO of RecycleBank, April 7, 2009; presentation by John Doerr, partner, Kleiner Perkins Caufield & Byers, "Seeking Salvation and Profit in Green Tech," March 2007, http://www.ted.com/index.php/talks/john_doerr_sees_salvation_and_profit_in_greentech.html (accessed April 15, 2009).

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37 Ibid.

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39 Pew interview with Michael Peck, director of Media, Institutional and Labor Relations in North America for GamesaUSA, April 3, 2009.

40 U.S. Department of Energy, "Electricity Delivery and Energy Reliability: Distributed Energy Program," May 17, 2006, http://www.eere.energy.gov/de/energy_storage.html (accessed April 26, 2009).

41 Steven Chu, quoted in Olson and Fri, eds., "National Academies Summit on America's Energy Future," Washington D.C., The National Academies Press, 2008, p. 63.

42 Cleantech Group™ LLC, *Cleantech Investment Monitor 2008 Annual Review and 4Q08 Quarterly*, 2009.

43 McKinsey & Company, "Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve," January 2009, http://globalghgcostcurve.bymckinsey.com/ (accessed March 10, 2009).

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46 Sari Krieger, "Honeywell's Building Automation Business Stands Out," *Clean Technology Insight*, February 2, 2009.

47 Honeywell International Inc. brochure, "Leveraging the Stimulus," April 2009, p. 2.

48 Honeywell International Inc. press release, "Honeywell Helps Pittsburgh Housing Authority Cut Utility Bills and Carbon Emissions," October 23, 2008, http://buildingsolutions.honeywell.com/Cultures/en-US/NewsEvents/NewsReleases/HACP.htm (accessed May 1, 2009).

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pollutants or hazardous/toxic air pollutants; are innovative and unique; provide a model for others to follow; and result in positive outcomes that are continuing/ sustainable. http://www.johnsoncontrols.com/publish/us/en/ sustainability/awards_and_recognition.html (accessed May 2, 2009).

52 Pew interview with Joy Clark-Holmes, director of Local Government and Market Solutions, Johnson Controls, March 23, 2009.

53 Companies that help drive demand for products and services in the clean energy economy, such as Austin Energy, are important to note. Austin Energy, like other utilities, invests in developing clean, renewable energy sources and provides incentives for its customers and suppliers to adopt energy-efficient technologies and practices, thereby creating a market demand for the clean energy economy. But while these businesses are critical to growing the clean energy economy, they are not included in our count of businesses and jobs. As noted in Appendix B, Pew's analysis captures only the producers and suppliers of the products and services in the clean energy economy, not the companies or institutions that drive demand—underscoring the fact that our count is conservative.

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57 Pew interview with Adam Tibbs, president of Project FROG, April 3, 2009.

58 Pew interview with Robert Fox, managing partner, Manko, Gold, Katcher & Fox, April 8, 2009.

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69 Cleantech Group™ LLC, *Cleantech Investment Monitor 2008 Annual Review and 4Q08 Quarterly*, 2009.

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100 Our 16 segments were based on 11 original segments identified by the Cleantech Group™, LLC, a trade association and consulting and research firm. *See* http://cleantech.com.

101 As defined by the Cleantech Group™, LLC, clean technology, or "cleantech," "represents a diverse range of products, services, and processes, all intended to provide superior performance at lower costs, while greatly reducing or eliminating negative ecological impact, at the same time as improving the productive and responsible use of natural resources." http://cleantech.com/about/cleantechdefinition.cfm (accessed May 3, 2009).

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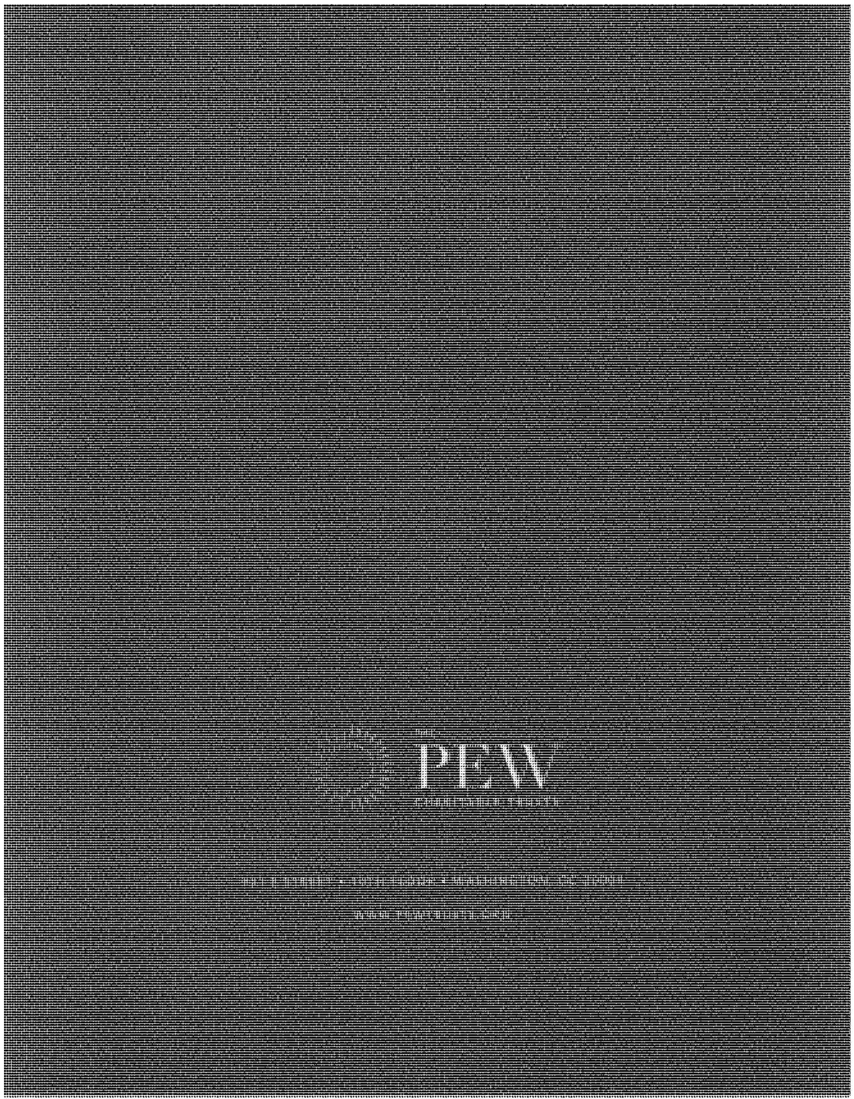
PEW

Senator BOXER. And what kind of power is it?

Mr. SIMS. That it is a rural electric cooperative.

Senator BOXER. Coal?

Mr. SIMS. Mostly coal, as is most of Utah.

Senator BOXER. If I could just suggest to you, just in the most humble and respectful way to you?

Mr. SIMS. Sure.

Senator BOXER. That I really, when I look at a study that is done by someone that has a special interest, I think you have to weigh that.

Mr. SIMS. Have your staff look at it. I think you will find it is——

Senator BOXER. So, therefore, I am just telling you because I do not want you to be misled.

Mr. SIMS. I understand.

Senator BOXER. When I see studies that are done by special interests about jobs, and it serves their purpose, it does not have as much weight with me as independent studies. And I just wanted you to know that.

Mr. SIMS. By other special interests, right?

Senator BOXER. Well, I do not think that U.C. Berkeley and the University of Illinois is a special interest, OK? But we could argue that. You worked for Senator Kasten, and I am sure you made those distinctions in those days.

I want to say to all of you how much I appreciate your time, your effort, your intelligence, how articulate you are. I am proud to have all of you here. It has been a fantastic day. This was kind of like the marathon.

And the last thing I am going to do is put in the record a letter which I am very excited about from the Metropolitan Water District of Southern California, written to Senators Kerry and myself. As the largest provider of drinking water in the United States, we greatly appreciate your efforts and it is a very, very supportive letter of our bill.

So, this has been really good. And if you have not had enough of this, come back tomorrow, because we are going to have another four panels starting at 9:30 a.m.

Thank you.

We stand adjourned.

[Whereupon, at 5:33 p.m. the committee was adjourned, to reconvene at 9:30 a.m. the following day.]

[An additional witness statement submitted for the record follows:]

TESTIMONY OF DR.KENNETH P. GREEN

BEFORE THE

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

"LEGISLATIVE HEARING ON S. 1733,
CLEAN ENERGY JOBS AND AMERICAN POWER ACT"

OCTOBER 28, 2009

Chairman Boxer, Senator Inhofe, Members of the Committee:

Thank you for inviting me to testify today on this important topic. Along with these remarks, I have submitted, for the record, two policy studies pertinent to today's topic. One, published in 2007, compares cap-and-trade with a revenue neutral carbon tax, and points out the many problems inherent in cap and trade. That study is "Climate Change: Caps vs. Taxes." The second study I'm submitting for the record is entitled "Climate Change: The Resilience Option," and is my most recent publication. My testimony here today represents my personal views, and should not be construed as the official position of the American Enterprise Institute, or any other persons or organizations.

Before I begin my remarks, I always like to list my three B's, my background, biases, and beliefs.

As to background, I am a biologist and environmental scientist by training, an economist by exposure, and a policy analyst by vocation: I've spent the last 15 years analyzing environmental policy in think tanks in the U.S. and Canada.

My biases are for solving environmental problems, whenever possible, with instruments that maximize freedom, opportunity, enterprise, and personal responsibility. Thus, I strongly favor true market-based remedies for environmental problems over command-and-control regulation. (I will observe here that cap-and-trade legislation is not truly market-based, as government sets a limit on emissions, rather than allowing a market to determine that level. Cap-and-trade, no matter how cleverly hidden behind misleading terminology, as it is in S. 1733, is more akin to rationing than it is to markets. We have written, elsewhere, about cap-and-trade's failings when it comes to greenhouse gas controls.)

Finally, my beliefs are based on reading the scientific literature as well as the IPCC climate science reports, and I believe that while greenhouse gases do retain heat in the atmosphere (making Earth habitable), the heat-retention capability of additional anthropogenic greenhouse gases is modest. I do not believe in predictive climate models, or most other forms of forecasting other than simple extrapolation for very modest periods of time.

That being said, I do believe that climate science has taught us something important that merits action. We have learned the Earth's climate is not the slow-moving system we thought it was. Rather, the climate is prone to sharp shifts into cooler and warmer conditions that can depart significantly from "average" temperatures for decades at a time. Acting to enhance climate resilience is an important task.

So, to the issue at hand: how can we best build U.S. resilience to global warming impacts?

First, I believe that we should shift our focus from mitigation of greenhouse gas emissions toward an adaptation agenda. We do not, at present, have the technologies needed to significantly curb greenhouse gas emissions without causing massive economic disruption, and without preventing the developing countries from developing, and lifting their billions of people out of squalor and poverty. The money and attention that we are spending on mitigation efforts is largely wasted – even if we shut the U.S. and the EU off completely, the trajectory of emissions from China and India will negate the environmental benefit of our self-sacrifice completely in only a few years. All that jacking up energy costs will do is deprive of us economic productivity which is the ultimate wellspring of our resilience and well-being.

Second, I believe that we should stop making things worse. That is, we should remove the misguided incentives that lead people to live in climatically fragile areas such as the water's edge, drought-prone locations, flood-prone locations, and so on.

At present, our federal and state governments exacerbate this risk-taking by acting as the insurer of last resort. When people who live at water's edge or in a flood plain are hit by storms or floods, governments intervene not only to rescue them and their property if possible, but then to provide rebuilding funds to let the people build right back where they are at risk. We are currently doing this in New Orleans, where people are re-building in an area that is still at risk from storm surges and levee failure. Undoubtedly, we'll do this in California, putting people right back into fire-prone areas they were burned out of last year.

As Charles Perrow observes in his book *Our Next Catastrophe*: "State-mandated pools have been established to serve as a market of last resort for those unable to get insurance, but the premiums are low and thus these have the perverse effect of subsidizing those who choose to live in risky areas and imposing excess costs on people living elsewhere. In addition, the private insurers are liable for the net losses of these pools, on a market-share basis. The more insurance they sell, the larger their liability for the uninsured. Naturally, they are inclined to stop writing policies where there may be catastrophic losses. The Florida and California coastlines are very desirable places to live and their populations have grown rapidly, but these handsome lifestyles are subsidized by residents living in the less desirable inland areas in the state, and, to some limited extent, by everyone in the nation."

Programs that subsidize climatic risk-taking should be phased out as quickly as possible, in favor of fully-priced insurance regimes. Rebuilding after disasters in climatically fragile areas should be discouraged. Eliminating risk subsidies would show people some of the true cost of living in climatically risky areas, and would, over time, lead them to move to climatically safer places where they can afford to insure their property and safety.

Third, we must look to our infrastructure. Another government action that leads people to live in harm's way is the failure to build and price infrastructure so that it is both sustainable, and resilient to change. Governments build highways, but generally without a pricing mechanism. Thus, no revenue stream is created to allow, for example, for the highway to be elevated if local flooding becomes a problem. There is also no price signal relayed to the users of the highway that reflects the climatic risk that their transportation system faces. The same is true of fresh-water infrastructure, wastewater infrastructure, electricity, and other infrastructure. Politicians love cutting ribbons on new "free" infrastructure. They're less prone toward having the cost of that infrastructure show up in terms of tolls or user fees.

Establishing market pricing of infrastructure would quickly steer people away from climatically fragile areas, dramatically reducing the costs of dealing with climate variability.

For example, let's consider our electricity supply. As long as governments distort the prices consumers pay for energy with subsidies, fuel mandates, renewable power mandates, and the like, electricity markets cannot effectively adapt to changing climatic conditions. If electricity markets were fully deregulated, and if full costs were passed onto consumers, price signals would be created for the electricity provider in terms of expanding or decreasing capacity and for the consumer in terms of the real cost of living in an environment subject to energy-consuming heat waves (or cold snaps). Privatization would create incentives for electricity conservation and for the acquisition of energy-efficient appliances and devices without any need for specific governmental efficiency standards. Further, electric companies would be driven to connect with one another to ensure reliability to their customers rather than doing the minimum possible to satisfy regulators.

And consider our water supply. Full pricing of water and full privatization of the water supply, drinking water plants, and wastewater treatment plants would ameliorate many climatic risks incrementally over time, including flooding, seawater intrusion, and coastal and river pollution from storm runoff. Charging the full price for water, from supply to disposal, would create a price signal for consumers regarding the real risks they face living in hydrologically sensitive areas and create incentives for conservation while producing a revenue stream to allow for expanded capability or the securing of alternative supplies. At some point, again, high prices could simply lead people to move away from areas that are hydrologically costly, such as cities dependent on a single winter snow pack that shrinks or a single major river that suffers reduced flow.

Finally, I would suggest that we trust in resilience, but tie up our camel. In the event that climate change does tend toward higher estimates put forward by the United Nations and other groups, it is reasonable to consider insurance options that might help deal with such climate changes. Such options might include government investment in geoengineering research, investment in research and development to advance technologies allowing the removal of greenhouse gases from the atmosphere

Climate variability, whether natural or man-made, does pose significant challenges to the health of our population, the maintenance of our infrastructure, and to our economic growth. Taking steps to make our society resilient in the face of climate variability is an important endeavor, and I applaud your hearing on the matter today.

Thank you for allowing me to speak to you today on this timely and important issue.

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Environmental Policy Outlook

Climate Change: Caps vs. Taxes

By Kenneth P. Green, Steven F. Hayward, and Kevin A. Hassett

As the Kyoto Protocol's 2012 expiration date draws near, a general theme dominates the global conversation: leadership and participation by the United States are critical to the success of whatever climate policy regime succeeds the Kyoto Protocol. Two general policy approaches stand out in the current discussion. The first is national and international greenhouse gas (GHG) emissions trading, often referred to as "cap-and-trade." Cap-and-trade is the most popular idea at present, with several bills circulating in Congress to begin a cap-and-trade program of some kind. The second idea is a program of carbon-centered tax reform—for example, the imposition of an excise tax based on the carbon emissions of energy sources (such as coal, oil, and gasoline), offset by reductions in other taxes. In this paper we will address the strengths and weaknesses of both ideas and the framework by which legislators should evaluate them.

The framing of a global climate regime presents a classic chicken-and-egg problem: the United States does not wish to enter into a regime of economically costly emission caps or taxes that would have the effect of driving industry and jobs to nations such as China and India that do not participate in such caps. China and India, however, are unlikely to enter into a restrictive regime unless the United States goes first, and even then, only so long as the policy regime does not threaten serious constriction of their economies. It is often assumed that if the United States goes first, developing nations will eventually follow, but this is by no means assured. Both China and India have repeatedly declared that they are not prepared to make even a delayed commitment at this time.

Given these policy uncertainties—and other uncertainties about the eventual impacts of climate change in terms of severity, distribution, and timing—there are two guideposts policymakers should keep in mind. The first is that the United States can only effectively impose a national regulatory regime (though such a regime could eventually be harmonized with international efforts). The second is that, given the current uncertainty, policy should conform as much as possible to a "no regrets" principle by which actions undertaken can be justified separately from their GHG emissions effects in the fullness of time, such that nonparticipation by developing nations will disadvantage the United States in the global marketplace as little as possible.

While the United States may wish to join with other nations in setting a post-Kyoto emissions goal, it should be wary of joining an international emissions-trading or other regulatory regime. One of the less-remarked-upon aspects of the Kyoto Protocol, and any prospective successor treaty on that same model, is that it represents an unprecedented kind of treaty obligation for the United States. Most treaties involve direct actions and policies of governments themselves, such as trade treaties that bind nations' tariff levels and affect the private sector of the economy only indirectly. Kyoto and its kin go beyond government policy to affect the private sector directly or require the

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government to control the private sector and the investment decisions of the private sector to an unprecedented degree. It is not governments that emit GHGs, after all. Between the asymmetries of legal and regulatory regimes across nations, the United States should think hard about the dilution of sovereignty that a binding GHG treaty represents, even if the United States agrees with the basic objective of reducing carbon emissions.

Problems with Emissions Trading for GHG

Some economists favor the idea of emissions trading for its elegance in achieving least-cost emissions reductions while avoiding the manifold difficulties of prescriptive "command-and-control" regulation from a centralized bureaucracy. But this is something of a false choice, as such regulation is a deeply troubled policy option. While trading may be superior to command-and-control, it is not necessarily superior to other alternatives, such as carbon-centered tax reform.

While trading may be superior to command-and-control, it is not necessarily superior to other alternatives, such as carbon-centered tax reform.

There are a number of emissions-trading success stories that, upon inspection, suggest significant limitations to the applicability of emissions trading for GHG emissions. Enthusiasts for cap-and-trade point first to our sulfur dioxide (SO_2) trading experience under the 1990 Clean Air Act Amendments. It is claimed that the costs of SO_2 abatement through trading turned out to be dramatically lower than economists had forecast for a prescriptive regime, wherein the Environmental Protection Agency (EPA) would have mandated control technologies on individual coal-fired power plants. But a closer look shows this success to have been uneven. There has been significant volatility in emission permit prices, ranging from a low of $66 per ton in 1997 to $860 per ton in 2006, as the overall emissions cap has been tightened, with the price moving up and down as much as 43 percent in a year.[1] Over the last three years, SO_2 permit prices have risen 80 percent a year, despite the EPA's authority to auction additional permits as a "safety valve" to smooth out this severe price volatility.

Several other aspects of the SO_2-trading program are of doubtful applicability to GHGs. First, SO_2 trading was only applied to a single sector: initially, only 110 coal-fired power plants were included in the system, but it subsequently expanded to 445 plants. While coal-fired power plants account for roughly one third of U.S. carbon dioxide (CO_2) emissions and will therefore be central to a GHG cap-and-trade program, a comprehensive GHG emissions-trading program will have to apply across many sectors beyond electric utilities, vastly complicating a trading system.

Second, SO_2 and CO_2 are not comparable targets for emissions reduction. Reducing SO_2 emissions did not require any constraint on end-use energy production or consumption. Coal-fired power plants had many low-cost options to reduce SO_2 emissions without reducing electricity production. Some switched to low-sulfur coal (abetted in large part by railroad deregulation in the 1980s, which made transport of Western low-sulfur coal more economical than previously). The cost of "scrubbers"—industrial devices which capture SO_2 and sequester it—turned out to be lower than predicted. Other utilities emphasized more use of natural gas. The impact on ratepayers and consumers was modest.

CO_2 is different: it is the product of complete fuel combustion. There is no "low-CO_2 coal," and the equivalent of SO_2 scrubbers does not yet exist in economical form.[2] At the margin there is some opportunity for GHG emissions reductions through substitution—increased use of natural gas (which emits less CO_2 per unit of energy than coal) and possibly nuclear power—but the inescapable fact is that any serious reduction in CO_2 emissions will require a suppression of fuel combustion. This is going to mean lower energy consumption and higher prices, at least in the intermediate term.

Even though confined to a segment of a single sector of energy use, the SO_2 emissions-trading regime was far from simple. There were complicated allocation formulas to distribute the initial emissions permits. Despite the best efforts to create objective criteria, at the end of the day, the allocation of emission permits involves some arbitrary discretion. For political reasons there were special subsidies and extra allowances for the benefit of high-sulfur coal interests. Most trading in the early years took place between power plants within the same company.

Establishing allowances and accounting systems for GHG emissions across industries is going to be vastly more difficult and highly politicized. The forest products industry, for example, will reasonably want credits for creating carbon sinks in the trees it plants and harvests, but the manufacturing sector that uses these wood products as a raw material will want credit for sequestering carbon. The difference will have to be split in some arbitrary manner that will surely introduce economic distortions in the marketplace. The auto industry will want credits for GHG innovations, while industries and businesses of all kinds will lobby for credits for reducing mobile source emissions from changes to their auto and truck fleets. There are going to be winners and losers in this allocation process. Multiply this problem across sectors and industries and it becomes evident that a GHG emissions-trading system is going to be highly complex and unwieldy, and too susceptible to rent-seeking influence in Washington. The problem of politically adjusting competing interests will be compounded on the international scale. The long-running diplomatic conflicts that can be observed over purported subsidies for aircraft (i.e., Boeing versus Airbus) and the European Union's agricultural subsidies and trade barriers are examples of the kinds of conflicts that will be endemic to any international emissions-trading scheme.

The favored solution to these problems is to over-allocate the number of initial permits both to ease the cost and to encourage the rapid start-up of a market for trades. This was the course the European Union took with its Emissions Trading System (ETS), and it has very nearly led to the collapse of the system. Because emissions permits were over-allocated, the price of emissions permits plummeted, and little—if any—emissions reductions have taken place because of the ETS. The over-allocation of initial permits merely postpones both emissions cuts and the economic pain involved. Economist Robert J. Shapiro notes:

> As a result of all of these factors and deficiencies, the ETS is failing to reduce European CO_2 emissions. . . . [T]he European Environmental Agency has projected that the EU is likely to achieve no more than one-quarter of its Kyoto-targeted reductions by 2012, and much of those "reductions" will simply reflect credits purchased from Russia or non-Annex-I countries [developing countries], with no net environmental benefits.[3]

As economist William Nordhaus observes:

> We have preliminary indications that European trading prices for CO_2 are highly volatile, fluctuating in a band and [changing] +/- 50 percent over the last year. More extensive evidence comes from the history of the U.S. sulfur-emissions trading program. SO_2 trading prices have varied from a low of $70 per ton in 1996 to $1500 per ton in late 2005. SO_2 allowances have a monthly volatility of 10 percent and an annual volatility of 43 percent over the last decade.[4]

Nordhaus points out the ramifications of such volatility, observing that "[s]uch rapid fluctuations would be extremely undesirable, particularly for an input (carbon) whose aggregate costs might be as great as petroleum in the coming decades," and that "experience suggests that a regime of strict quantity limits might become extremely unpopular with market participants and economic policymakers if carbon price variability caused significant changes in inflation rates, energy prices, and import and export values."[5]

Nordhaus is not alone in this concern about price volatility. Shapiro similarly observes:

> Under a cap-and-trade program strict enough to affect climate change, this increased volatility in all energy prices will affect business investment and consumption, especially in major CO_2 producing economies such as the United States, Germany, Britain, China and other major developing countries.[6]

Additional pitfalls and dilemmas of emissions trading can be seen through a review of the spectacular trading failure of the RECLAIM (Regional Clean Air Incentives Market) emissions-trading program in Southern California. Launched in 1994 after three years of development, RECLAIM set in motion an emissions-trading program targeting SO_2 and nitrogen oxides (NO_x) emissions, and eventually hoped to expand to include volatile organic compound (VOC) emissions. All three types of emissions are important precursors to ozone formation in the greater Los Angeles air basin. RECLAIM, for the first time, offered swaps between stationary and mobile sources: stationary sources such as oil refineries could help reach their emissions reduction targets by purchasing old, high-polluting automobiles and trucks and taking them off the road—a cost-effective measure in a voluntary demonstration program. The South Coast Air Quality Management District (SCAQMD) estimated that SO_2 and NO_x would be reduced by fourteen and eighty tons per day, respectively, by the year 2003, at half the cost of the usual prescriptive method of regulation.[7] There was great public support and enthusiasm for the program at the outset.

RECLAIM never came close to operating as predicted, and was substantially abandoned in 2001. Between 1994 and 1999, NO_x levels fell only 3 percent, compared to a 13 percent reduction in the five-year period before RECLAIM. There was extreme price volatility aggravated by California's electricity crisis of 2000. NO_x permit prices ranged from $1,000 to $4,000 per ton between 1994 and 1999, but soared to an average price of $45,000 per ton in 2000, with some individual trades over $100,000 per ton. Such high prices were not sustainable, and SCAQMD removed electric utilities from RECLAIM in 2001. SCAQMD also dropped its plan to expand RECLAIM to VOCs. Despite the hope that RECLAIM would be simple and transparent, there were serious allegations of fraud and market manipulation, followed by the inevitable lawsuits and criminal investigations.

One particular problem with RECLAIM that is likely to plague any international GHG emissions-trading regime is the lack of definite property rights to the emissions allowances the program creates. A cliché of the moment is that industry would like some clarity and certainty about any prospective GHG regulatory regime. A cap-and-trade program, however, cannot provide certainty precisely because emissions allowances are not accorded real property rights by law.[8] The government can change the rules at any time, making emissions allowances worthless. This is exactly what happened to electric utilities in Los Angeles: their allowances were terminated, and the utilities were subsequently required to install specified emissions-control technologies and to pay fines for excess emissions. In effect, some Los Angeles firms had to pay three times over for emissions reductions.

A GHG emissions-trading scheme on an international level will be even more vulnerable to these kinds of unpredictable outcomes. To the extent that a GHG emissions-trading program results in international cross-subsidization of the economies of trading partners, it is going to be politically unsustainable in the long run. An international emissions-trading program is also unlikely to survive noncompliance by some of its members.

There are two final, overriding reasons to be doubtful about global emissions trading. It is possible that the defects of previous emissions-trading programs could be overcome with more careful design and extended to an international level, though this would require an extraordinary feat of diplomacy and substantial refinements of international law. Even if such improvement could be accomplished, it would not provide assurance against the prospect that the cost of such a system might erode the competitiveness of the U.S. economy against developing nations that do not join the system.

The second reason for skepticism about global emissions trading is that it fails the "no regrets" test. It is considered bad form nowadays to express doubt or skepticism about the scientific case for rapid and dangerous global warming in the twenty-first century. If warming is either less pronounced than some current forecasts predict or if emissions reductions have limited effect in moderating future temperature rise, however, a severe global emissions-reduction policy through emissions trading (on the order of a minimum 50 percent cut by 2050) could turn out to be the costliest public policy mistake in human history, with the costs vastly exceeding the benefits.

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Could instituting a tax on the carbon emissions released by fuel use, as part of a revenue-neutral tax reform package, pass these two tests? We believe it could.

Advantages of a Revenue-Neutral, Carbon-Centered Tax Reform

Most economists believe a carbon tax (a tax on the quantity of CO_2 emitted when using energy) would be a superior policy alternative to an emissions-trading regime. In fact, the irony is that there is a broad consensus in favor of a carbon tax everywhere except on Capitol Hill, where the "T word" is anathema. Former vice president Al Gore supports the concept, as does James Connaughton, head of the White House Council on

Environmental Quality during the George W. Bush administration. Lester Brown of the Earth Policy Institute supports such an initiative, but so does Paul Anderson, the CEO of Duke Energy. Crossing the two disciplines most relevant to the discussion of climate policy—science and economics—both NASA scientist James Hansen and Harvard University economist N. Gregory Mankiw give the thumbs up to a carbon tax swap.[9]

There are many reasons for preferring a revenue-neutral carbon tax regime (in which taxes are placed on the carbon emissions of fuel use, with revenues used to reduce other taxes) to emissions trading. Among them are:

- **Effectiveness and Efficiency.** A revenue-neutral carbon tax shift is almost certain to reduce GHG emissions efficiently. As economist William Pizer observes, "Specifically, a carbon tax equal to the damage per ton of CO_2 will lead to exactly the right balance between the cost of reducing emissions and the resulting benefits of less global warming."[10] Despite the popular assumption that a cap-and-trade regime is more certain because it is a quantity control rather than a price control, such a scheme only works in very limited circumstances that do not apply to GHG control. The great potential for fraud attendant on such a system creates significant doubt about its effectiveness, as experience has shown in both theory and practice in the gyrations of the European ETS.

  The likelihood of effectiveness also cannot be said for regulations such as increased vehicle fuel economy standards. In fact, such regulations can have perverse effects that actually lead to increased emissions. By making vehicles more efficient, one reduces the cost of a unit of fuel, which would actually stimulate more driving, and, combined with increasing traffic congestion, could lead to an increase in GHG emissions rather than a decrease.

  As Harvard researchers Louis Kaplow and Steven Shavell point out, "The traditional view of economists has been that corrective taxes are superior to direct regulation of harmful externalities when the state's information about control costs is incomplete," which, in the case of carbon emissions reductions, it most definitely is.[11] And when it comes to quantity controls (as a cap-and-trade system would impose), Pizer found that

  > My own analysis of the two approaches [carbon taxes vs. emission trading] indicates that price-based greenhouse gas (GHG) controls are much more desirable than quantity targets, taking into account both the potential long-term damages of climate change, and the costs of GHG control. This can be argued on the basis of both theory and numerical simulations.

  Pizer found, in fact, that a carbon-pricing mechanism would produce expected net gains five times higher than even the best-designed quantity control (i.e., cap-and-trade) regime.[12]

- **Incentive Creation.** Putting a price on the carbon emissions attendant on fuel use would create numerous incentives to reduce the use of carbon-intensive energy. The increased costs of energy would flow through the economy, ultimately giving consumers incentives to reduce their use of electricity, transportation fuels, home heating oil, and so forth. Consumers, motivated by the tax, would have incentives to buy more efficient appliances, to buy and drive more efficient cars, and to better insulate their homes or construct them with more attention to energy conservation. A carbon tax would also create incentives for consumers to demand lower-carbon power sources from their local utilities. A carbon tax, as its cost flowed down the chains of production into consumer products, would lead manufacturers to become more efficient and consumers to economize in consumption. At all levels in the economy, a carbon tax would create a profit niche for environmental entrepreneurs to find ways to deliver lower-carbon energy at competitive prices. Finally, a carbon tax would also serve to level (somewhat) the playing field among solar power, wind power, nuclear power, and carbon-based fuels by internalizing the cost of carbon emission into the price of the various forms of energy.

- **Less Corruption.** Unlike carbon cap-and-trade initiatives, a carbon tax would create little incentive or opportunity for rent-seeking or cheating. As William Nordhaus explains:

  > A price approach gives less room for corruption because it does not create artificial scarcities, monopolies, or rents. There are no permits transferred to countries or leaders of countries, so they cannot be sold abroad for

wine or guns. . . . In fact, a carbon tax would add absolutely nothing to the instruments that countries have today.[13]

Without the profit potential of amassing tradable carbon permits, industry groups would have less incentive to try to get credits for their favored but non-competitive energy sources. That is not to say that tax-based approaches are immune from corruption, for they certainly are not. If set too far down the chain of production or set unevenly among energy sources, carbon taxes could well lead to rent-seeking, political favoritism, economic distortions, and so on. Foreign governments might have an incentive to undermine a trading scheme by offering incentives to allow their manufacturers to avoid the cost of carbon trading. A tax on fuels proportionate to their carbon content, levied at the point of first sale, should be less susceptible to corruption, and by delivering revenue to the government rather than to private entities, should create incentives more aligned with the government's objective.

A carbon tax, as its cost flowed down the chains of production into consumer products, would lead manufacturers to become more efficient and consumers to economize in consumption.

- **Elimination of Superfluous Regulations.** Because a carbon tax would cause carbon emissions to be reduced efficiently across the entire market, other measures that are less efficient—and sometimes even perverse in their impacts—could be eliminated. With the proper federal carbon tax in place, there would be no need for corporate average fuel economy standards, for example. California's emissions-trading scheme, likewise, would be superfluous, and its retention only harmful to the Golden State. As regulations impose significant costs and distort markets, the potential to displace a fairly broad swath of environmental regulations with a carbon tax offers benefits beyond GHG reductions.

- **Price-Stabilization.** As the experiences of the European ETS and California's RECLAIM show us, pollution-trading schemes can be easily gamed, resulting in significant price volatility for permits. Imagine one's energy bill jumping around as permits become more or less available due to small changes in economic conditions. A carbon tax would be predictable, and by raising the overall price of energy to include the tax, the portion of energy cost per unit that stems from fluctuation in market rates for fossil fuels shrinks as a percentage of the whole. That shrinkage makes the price of a given form of energy less susceptible to volatility every time there is a movement in the underlying production costs.

- **Adjustability and Certainty.** A carbon tax, if found to be too stringent, could be relaxed relatively easily over a time-frame, allowing for markets to react with certainty. If found too low to produce results, a carbon tax could easily be increased. In either event, such changes could be phased in over time, creating predictability and allowing an ongoing reassessment of effectiveness via observations about changes in the consumption of various forms of energy. A cap-and-trade system, by contrast, is more difficult to adjust because permits, whether one is the seller or the buyer, reflect significant monetary value. Permit traders would demand—and rightly so—compensation if what they purchased in good faith has been devalued by a governmental deflation of the new "carbon currency." In addition, sudden changes in economic conditions could lead to significant price volatility in a cap-and-trade program that would be less likely under a carbon-tax regime.

- **Preexisting Collection Mechanisms.** Whether at local, state, or federal levels, carbon taxes could be levied and collected through existing institutions with extensive experience in enforcing compliance, and through ready-made statutes to back up their actions. The same cannot be said for emissions-trading schemes that require the creation of new trading markets, complete with new regulations and institutions to define and enforce the value of credits.

- **Keeping Revenue In-Country.** Unlike an international cap-and-trade regime, carbon taxes—whether done domestically or as an internationally agreed-upon value—have the advantage of keeping tax payments within individual countries. This could strongly reduce the opposition to international action that has, until this point, had a strong implication of wealth redistribution overlaid on the policy discussion.

This dynamic leads to a second reason why a carbon tax is a better fit for U.S. climate policy: it offers an international analogue to our federalist approach to public policy innovation within the United States. As we have seen, there is reason to doubt the long-run effectiveness and sustainability of the EU's emissions-trading program. If the United States adopts a carbon tax approach, we will be able to compare the effectiveness of tax versus emissions trading in short order.

- **Mitigation of General Economic Damages.** As energy is one of the three most important variable inputs to economic production (along with labor and capital), raising the cost of energy would undoubtedly result in significant economic harm. Using the revenues generated from a carbon tax to reduce other taxes on productivity (taxes on labor or capital) could mitigate the economic damage that would be produced by raising energy prices. The most likely candidates for a carbon tax tradeoff would be the corporate income tax (the U.S. rate is currently among the highest in the industrialized world) and payroll taxes, the latter of which would lower the cost of employment and help offset the possibly regressive effects of higher energy prices on lower-income households. But across-the-board income tax rate cuts and further cuts in the capital gains tax could also be considered.

  Few other approaches offer this potential. Regulatory approaches such as increasing vehicle efficiency standards do not because they mandate more expensive technologies and allow the costs to be passed on to consumers without offsets (unless they are subsidized), in which case it is the general taxpayer whose waller shrinks. Emissions-trading would allow for this if one auctioned all initial permits and used the revenue to offset other taxes. The vast majority of trading systems, however, begin with the governing entity distributing free emission credits to companies based on historical emission patterns rather than having an open auction for permits that would produce such revenue streams. Without an auction, the revenues in a trading scheme accrue only to private companies that trade in carbon permits, while the companies buying permits would pass the cost on to consumers. International emissions-trading approaches such as Kyoto's clean development mechanism are worse still: the beneficiaries of the scheme are likely to be foreign governments or private entities that can reduce (or pretend to reduce) carbon emissions more efficiently, leaving Americans with higher energy prices and no revenue stream to offset the negative impacts on productivity.

Exploring the Parameters of Carbon-Centered Tax Reform

Published estimates of an initial optimal carbon tax on fuels are in the range of \$10 to \$20 per ton of CO_2 emitted (in 2005 dollars). Nordhaus, for example, estimates the optimal rate for a tax implemented in 2010 to be \$16 per ton of carbon and rapidly rising over time.[14] We will focus primarily on a tax rate of \$15 per ton of CO_2, while also providing enough information to allow a reader to consider the likely impact of a range of possible taxes.

- **Background on Emissions.** According to the U.S. Energy Information Administration, emissions of CO_2 in the United States in 2005 equaled 6,009 million metric tons (MMT) of CO_2, an increase of twenty MMT over 2004.[15] Emissions have grown at an annual rate of 1.2 percent between 1990 and 2005. Recently, the rate has slowed, with the average annual rate between 2000 and 2005 equaling 0.5 percent.

- **Price Impacts.** Table 1, on the following page, shows the price impacts of a \$15 per ton CO_2 tax under the assumption that the tax is fully passed forward. The price shown for gasoline is not in addition to that on crude oil (i.e., it is not a double-tax). It is included to show how the price levied on crude oil would change the price of the refined product.[16] This provides a rough guide to the excise tax equivalent price impacts of a tax on CO_2. We can scale the tax rates to evaluate different carbon taxes. For example, a \$10 per ton tax on CO_2 would raise the price of coal by \$28.55 x 0.66 = \$18.84.

  A \$15 CO_2 tax would raise the price of gasoline by 14¢ per gallon. A similar calculation can be made for coal-fired electricity. Using the most recent data from EPA's Emissions & Generation Resource Integrated Database (eGRID), we calculate that the average emission rate for coal-fired power plants is 2,395 pounds of CO_2 per megawatt-hour (MWh) of electricity. A \$15 per ton CO_2 tax would raise the price of coal-fired electricity by 1.63¢ per kilowatt-hour (kWh), or 20 percent at an average electricity price of 8.3¢ per kWh.

Table 2 shows the impact of a $15 per ton carbon tax on the price of major fuels used in electricity generation. Fuel prices are prices at which the carbon tax would likely be applied.[17] Not surprisingly, coal is most heavily impacted by a carbon tax, with coal's price rising by more than three-quarters with a tax of this magnitude.

- **Behavioral Responses and Revenue.** The higher energy prices in table 2 should bring about a reduction in the demand for carbon-intensive fuels. A full analysis of equilibrium changes in carbon emissions requires a Computational General Equilibrium (CGE) model, an exercise that is beyond the scope of this paper. We can, however, make a rough calculation using previously published results from CGE models. Here, we extrapolate results from the analysis of Bovenberg and Goulder of a $25 per ton tax on carbon.[18] Table 3 presents the price and output changes for fossil fuels following the imposition of the carbon tax in Bovenberg and Goulder's study. We compute the arc elasticity as the ratio of the percentage output change to price change.

These response elasticities are not price elasticities in the usual sense, since they are the outcome of the entire general equilibrium response to the tax. These responses, for example, include a shift in electricity production away from coal toward natural gas and oil.[19] They are also relatively short-run responses, on the order of three to five years following the phased-in introduction (over three years) of the carbon tax.

The elasticities from table 3 combined with the price increases in table 2 imply the reductions in fuel use and carbon emissions seen in table 4.

TABLE 1

PRICE IMPACTS OF A $15 CO_2 TAX

Energy Unit	Coal Short Ton	Crude Oil Barrel	Natural Gas mcf	Gasoline Gallon
MT C/Quad Btu	25,980,000	20,300,000	14,470,000	19,340,000
Mt CO_2/Quad Btu	95,260,000	74,433,333	53,056,667	70,913,333
Btu/Energy Unit	19,980,000	5,800,000	1,027,000	124,167
Mt CO_2/Energy Unit	1.903	0.432	0.054	0.009
Tax/Energy Unit	$28.55	$6.48	$0.81	$0.14

SOURCES: Carbon content of fuels from www.eia.doe.gov/environment.html; energy content of fuels from U.S. Department of Energy (DOE), Energy Information Administration (EIA), *Annual Energy Review 2005*, DOE/EIA-0384(2005), Washington, DC: EIA, 2006.

TABLE 2

SHORT-RUN PRICE EFFECTS OF A $15 CO_2 TAX

Energy Source	Unit	Price Per Unit ($)	Tax Per unit of Energy	Price Change (%)
Coal	short ton	$34.29	28.55	83.3
Crude Oil	barrel	$60.23	6.48	10.8
Natural Gas	thousand cubic feet	$8.53	0.82	9.6

SOURCE: Prices are 2006 averages as reported by Energy Information Administration (EIA). Coal statistics from EIA, "Receipts, Average Cost and Quality of Fossil Fuels," available at www.eia.doe.gov/cneaf/electricity/epm/table4_2.html; crude oil statistics from EIA, "Refiner Acquisition Cost of Crude Oil," available at http://tonto.eia.doe.gov/dnav/pet/pet_pri_rac2_dcu_nus_a.htm; and natural gas statistics from EIA, "Natural Gas Prices," available at http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm. Unit taxes computed from table 1.

NOTE: Tax is assumed to be fully passed forward.

TABLE 3

IMPLIED OUTPUT ELASTICITIES

	Price Change (%)	Output Change (%)	Output Elasticity
Coal Mining	54.50	-19.10	-0.350
Oil	13.20	-2.10	-0.159
Natural Gas	13.20	-2.10	-0.159

SOURCE: A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?" in *Distributional and Behavioral Effects of Environmental Policy*, eds. Carlo Carraro and Gilbert E. Metcalf (Chicago: University of Chicago Press, 2000), table 2.2.

NOTE: Output elasticity is the ratio of the percent change in quantity demanded divided by the percent change in price, multiplied by negative one.

As table 4 shows, CO_2 emissions are reduced by 663 million metric tons, a decline of 11 percent. Most of the reduction in emissions comes from reduced coal use. A static estimate of CO_2 tax revenue (ignoring the behavioral response) suggests that a $15 tax would raise $90.1 billion per year in the near term.[20] Allowing for the emissions reductions calculated in table 4, the tax would raise $80.2 billion per year. Clearly, the tax would raise less money in future years as greater reductions in carbon emissions occurred through improvements in efficiency, fuel switching, or new technologies like carbon capture and sequestration.[21] The revenue estimate, however, does not factor in growth in demand for electricity nor the baseline growth in carbon emissions that would result in the absence of any carbon policy.

Applying this approach to different carbon tax rates gives the results for emissions reductions and tax revenues seen in table 5.

While these results are useful for providing a ballpark estimate of the impact of a carbon tax, more detailed modeling will be required to refine them further. Our estimates are broadly consistent with results from more detailed CGE modeling of U.S. carbon policies.[22]

TABLE 4
EMISSIONS REDUCTIONS FOR A $15 TAX

Energy Source	Output Change (%)	CO_2 Emissions (MMT)	Reduction in CO_2 Emissions (MMT)
Coal	−29.2	2,046	597.1
Crude Oil	−1.7	2,832	48.4
Natural Gas	−1.5	1,130	17.2
Total	N/A	6,009	662.8

SOURCE: Authors' calculations.

TABLE 5
VARYING THE TAX RATE

Tax Rate Per Ton ($)	Emissions Reductions (%)	Tax Revenue ($ billions, annual rate)
10	7.40	55.7
15	11.0	80.2
20	14.7	102.5
25	18.4	122.6

SOURCE: Authors' calculations.

TABLE 6
CARBON TAXES AS A SHARE OF OTHER TAXES

Tax Rate Per Ton ($)	Tax Revenue ($ billions)	Personal Income Tax (%)	Corporate IncomeTax (%)	Payroll Taxes (%)
10	55.7	6.0	20.0	7.0
15	80.2	8.6	28.8	10.1
20	102.5	11.1	36.8	12.9
25	122.6	13.2	44.1	15.4

SOURCE: Authors' calculations.

- **Potential Uses of Revenue.** Carbon tax revenues could be used for a number of purposes, such as lowering payroll and corporate income taxes, funding tax relief to low-income earners most affected by increased energy prices, or a combination of these. Table 6 reports the carbon tax revenue from table 5 as a percentage of various tax collections in 2005, as reported in the most recent administration budget submission.

A $15 per ton CO_2 tax raises enough revenue to reduce the corporate income tax by over one-quarter and income or payroll taxes by roughly 10 percent. In a policy brief for the Brookings Institution and the World Resources Institute, economist Gilbert Metcalf estimated that a rebate of the employer and employee payroll tax contribution on the first $3,660 of earnings per worker in 2003 would be sufficient to make the carbon tax both revenue- and distributionally neutral.[23]

Distributional neutrality may well impact the desirability and political feasibility of a carbon tax, but there are efficiency considerations as well. There is substantial literature on the "double dividend" that examines the economic conditions under which a carbon tax can be paired with a reduction in other taxes in a manner that improves the overall efficiency of the economy. Where such a double dividend is available, a carbon tax swap would be desirable, even if the environmental benefit of reduced carbon emissions failed to be realized.

The concept of the double dividend stems from the observation that a tax on an environmental externality not only helps curb the externality (dividend 1), but also provides revenue with which other distorting taxes can be reduced, thereby providing efficiency gains (dividend 2).[24]

The double dividend comes in different levels.[25] The "weak" double dividend states that if one has an economically distorting tax, using environmental tax proceeds to lower it provides *greater efficiency gains* than returning the proceeds lump sum to those who pay the environmental tax. An intermediate form of the double dividend hypothesis is that there exists a distortionary tax, such that using environmental tax proceeds to lower this tax will *improve welfare*, setting aside environmental benefits.[26] A strong form claims that a welfare gain will occur when environmental proceeds replace those of the typical distorting tax.

A tax swap would create economy-wide incentives for energy efficiency and lower-carbon energy, and by raising the price of energy, would also reduce energy use.

The weak double dividend is uncontroversial,[27] while the strong double dividend is somewhat more controversial.[28] Criticisms notwithstanding, logic suggests that the pursuit of a strong double dividend is desirable as a matter of public policy. To that end, it would seem much more desirable in terms of efficiency to pursue capital tax reduction as a revenue feedback than other choices, as the current treatment of capital in the tax code is quite far from the optimal tax of zero, and the efficiency gains from a reduction in a payroll tax would likely be minimal if labor is, as is generally accepted, supplied relatively inelastically.

It should be noted that cap-and-trade systems and carbon-tax systems can be designed so they are quite similar. If, for example, emissions are capped and permits are auctioned off, then one could, after observing the auction price, set a carbon tax that leads to a similar emissions and revenue outcome. Cap-and-trade systems, however, generally have been pursued as an alternative to revenue-raising taxes, and often allocate the permits according to some formula rather than through an auction. For the purposes of exposition, we compared a carbon tax to this latter form of the cap-and-trade system. One should remember that cap-and-trade proposals can be adjusted to raise revenues, and the revenues could then be used to pursue the double dividend. In that case, the relative merits of a carbon tax would be diminished.

Achieving a More Efficient System

A cap-and-trade approach to controlling GHG emissions would be highly problematic. A lack of international binding authority would render enforcement nearly impossible, while the incentives for cheating would be extremely high. The upfront costs of creating institutions to administer trading are significant and likely to produce entrenched bureaucracies that clamor for ever-tighter controls on carbon emissions. Permit holders will see value in further tightening of caps, but will resist efforts outside the cap-and-trade system that might devalue their new carbon currency. Higher energy costs resulting from trading would lead to economic slowdown, but as revenues would flow into for-profit coffers (domestically or internationally), revenues would be unavailable for offsetting either the economic slowdown or the impacts of higher energy prices on low-income earners.

A program of carbon-centered tax reform, by contrast, lacks most of the negative attributes of cap-and-trade, and could convey significant benefits unrelated to GHG reductions or avoidance of potential climate harms, making this a no-regrets policy. A tax swap would create economy-wide incentives for energy efficiency and lower-carbon energy, and by raising the price of energy would also reduce energy use. At the same time, revenues generated would allow the mitigation of the economic impact of higher energy prices, both on the general economy and on the lower-income earners who might be disproportionately affected by such a change. Carbon taxes would be more difficult to avoid, and existing institutions quite adept at tax collection could step up immediately. Revenues would remain in-country, removing international incentives for cheating or insincere participation in carbon-reduction programs. Most of these effects would remain beneficial even if science should determine that reducing GHG emissions has only a negligible effect on mitigating global warming.

A modest carbon tax of $15 per ton of CO_2 emitted would result in an 11 percent decline in CO_2 emissions, while raising non–coal-based energy forms modestly. Coal-based energy prices would be affected more strongly, which is to be expected in any plan genuinely intended to reduce GHG emissions. A number of possible mechanisms are available to refund the revenues raised by this tax. On net, these tools could significantly reduce the economic costs of the tax and quite possibly provide economic benefits.

For these reasons, we conclude that if aggressive actions are to be taken to control GHG emissions, carbon-centered tax reform—not GHG emission trading—is the superior policy option.

AEI editorial associate Nicole Passan worked with Messrs. Green, Hayward, and Hassett to edit and produce this Environmental Policy Outlook.

Notes

1. United States Environmental Protection Agency (EPA), "Progress Reports," available at www.epa.gov/airmarkets/progress/progress-reports.html.

2. Sequestration projects currently appear to be not only very expensive, but they also reduce net power generation by as much as 20 percent, further aggravating the cost that will be passed along to consumers and rate payers.

3. Robert J. Shapiro, "Addressing the Risks of Climate Change: The Environmental Effectiveness and Economic Efficiency of Emissions Caps and Tradable Permits, Compared to Carbon Taxes," February 2007, 22, available at www.the americanconsumer.org/Shapiro.pdf.

4. William Nordhaus, "Life after Kyoto: Alternative Approaches to Global Warming Policies" (NBER working paper no. W11889, December 2005), 15.

5. Ibid., 22.

6. Robert J. Shapiro, "Addressing the Risks of Climate Change: The Environmental Effectiveness and Economic Efficiency of Emissions Caps and Tradable Permits, Compared to Carbon Taxes."

7. RECLAIM covered 390 stationary sources of NOx and fourteen stationary sources of SO_2, which represented only 17 percent of total basin-wide NO_x emissions and 31 percent of basin-side SO_2 emissions.

8. The Clean Air Act forbids it, in fact. SCAQMD's RECLAIM regulations read: "An RTC [RECLAIM Trading Credit] shall not constitute a security or other form of property." Section 4 of the RECLAIM regulations reiterated this point: "Nothing in District rules shall be construed to limit the District's authority to condition, limit, suspend, or terminate any RTCs or the authorization to emit which is represented by a Facility Permit." (Cited in James L. Johnston, "Pollution Trading in La-La Land," *Regulation* [Fall 1991], available at www.cato.org/pubs/regulation/reg17n3-johnston.html.)

9. Carbon Tax Center, "Who Supports," available at http://carbontax.wrkng.net/who-supports/.

10. William Pizer, "Choosing Price or Quantity Controls for Greenhouse Gases," *Resources for the Future Climate Issues Brief* 17 (July 1999).

11. Louis Kaplow and Steven Shavell, "On the Superiority of Corrective Taxes to Quantity Regulation," *American Law and Economics Review* 4, no. 1 (2002).

12. William Pizer, "Choosing Price or Quantity Controls for Greenhouse Gases."

13. William Nordhaus, "Life after Kyoto: Alternative Approaches to Global Warming Policies," 15.

14. Ibid.

15. U.S. Department of Energy (DOE), Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States 2005*, DOE/EIA-0573(2005), Washington, DC: DOE, 2006. Total GHG emissions equaled 7,147 million metric tons CO_2 equivalent using hundred-year global warming potentials. Note that a simple conversion of other GHGs (i.e., methane, nitrous oxides, HFCs, and PFCs) does not exist. The global warming potential depends on the time horizon. We focus on CO_2 only in this study, though, ideally, a carbon tax would also tax these non-CO_2 emissions.

16. This is a standard assumption borne out by CGE modeling. See, for example, A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?" in *Distributional and Behavioral Effects of Environmental Policy*, eds. Carlo Carraro and Gilbert. E. Metcalf (Chicago: University of Chicago Press, 2000), 45–85.

17. We assume the tax on coal would be applied for electric utilities and major industrial coal users. Note that 91 percent of domestic and imported coal is consumed by electric utilities. (DOE, EIA, *Emissions of Greenhouse Gases in the United States 2005*.) The tax on crude oil is levied at refineries, and the tax on natural gas at the city gate.

18. A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?"

19. Increased coal prices could also lead to increased demand for imported oil, an important policy consideration outside the scope of this paper.

20. Carbon taxes can be reported in either units of carbon or CO_2. To convert a tax rate per unit of carbon dioxide to a rate per unit of carbon, multiply the CO_2 rate by 44/12 (the mass difference between carbon and CO_2). Thus, a tax of $10 per ton of CO_2 is equivalent to a tax of $36.67 per ton of carbon.

21. The recent coal study by researchers at the Massachusetts Institute of Technology suggests that carbon capture and sequestration is cost competitive at a carbon price of $30 per ton of CO_2. See John Deutch and Ernest Moniz, *The Future of Coal* (Massachusetts Institute of Technology, 2007), available at http://web.mit.edu/coal/.

22. Sergey Paltsev et al., *Assessment of U.S. Cap-and-Trade Proposals*, report 146 (Cambridge, MA: MIT Joint Program on the Science and Policy of Global Change, 2007), available through http://mit.edu/globalchange/www/abstracts.html#top.

23. Gilbert Metcalf, *A Green Employment Tax Swap: Using a Carbon Tax to Finance Payroll Tax Relief* (Washington, DC: Brookings Institution–World Resources Institution, 2007).

24. Don Fullerton and Gilbert E. Metcalf, "Environmental Taxes and the Double Dividend Hypothesis: Did You Really Expect Something for Nothing?" *Chicago-Kent Law Review* 73, no. 1 (1998): 221–56.

25. See Lawrence H. Goulder, "Environmental Taxation and the 'Double Dividend': A Reader's Guide," *International Tax and Public Finance* 2 (1995): 157–83, for a thorough taxonomy of the various double dividends. Also see A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?"

26. The terminology of intermediate and strong double dividends is due to Goulder, "Environmental Taxation and the 'Double Dividend': A Reader's Guide."

27. Mustafa Babiker, Gilbert E. Metcalf, and John Reilly, "Tax Distortions and Global Climate Policy," *Journal of Environmental Economics and Management* 46 (2003): 269–87. Babiker et al. show that it is possible, however, to find taxes such that lump-sum replacement dominates, lowering a distortionary tax.

28. A. Lans Bovenberg and Ruud de Mooij, "Environmental Levies and Distortionary Taxation," *American Economic Review* 84, no. 4 (1994): 1085–89. See also Lawrence H. Goulder, "Environmental Taxation and the 'Double Dividend': A Reader's Guide."

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Climate Change: The Resilience Option

By Kenneth P. Green

> "The willow which bends to the tempest, often escapes better than the oak which resists it; and so in great calamities, it sometimes happens that light and frivolous spirits recover their elasticity and presence of mind sooner than those of a loftier character."
>
> —Albert Schweitzer

The Earth's climate is prone to sharp changes over fairly short periods of time. Plans that focus simply on stopping climate change are unlikely to succeed; fluctuations in the Earth's climate predate humanity. Rather than try to make the climate static, policymakers should focus on implementing resilience strategies to enable adaptation to a dynamic, changing climate. Resilience strategies can be successful if we eliminate current risk subsidies and privatize infrastructure.

Recent climate research tells us that our climate is not the placid, slow-changing system people assume it to be. Instead, it is prone to sharp changes over fairly short periods of time. Whether those changes are natural or caused by human actions, we now know that we live in a world of greater climatic risks. Previous generations did not think about, plan for, or factor in these risks when they sited their cities and decided how to build and manage them. While planning was done for weather in what was considered a largely predictable system, little thought was given to making cities resilient to climate variability. As efforts to reduce greenhouse gas (GHG) emissions fail, we need to consider alternative plans and actions to reduce the risks we face.

The United Nations Intergovernmental Panel on Climate Change (IPCC) has always discussed the idea of adaptation to climate change as a second- or third-best response—something to be done only after every possible effort has been made to reduce GHG emissions. Both governmental and environmental groups have generally been hostile to adaptation-based responses to climate change, as they view such approaches as surrender—an acceptance of the idea that GHG emissions will continue, that the climate will change, and that people will come to believe they can adapt. They fear that a focus on adapting to climate change would detract from a focus on mitigating emissions.

There will be arguments about mitigating GHG emissions for many years (and perhaps decades) to come, but our new understanding of how variable our climate can be suggests we should broaden our climate policy focus by

Key points in this Outlook:

- [illegible]
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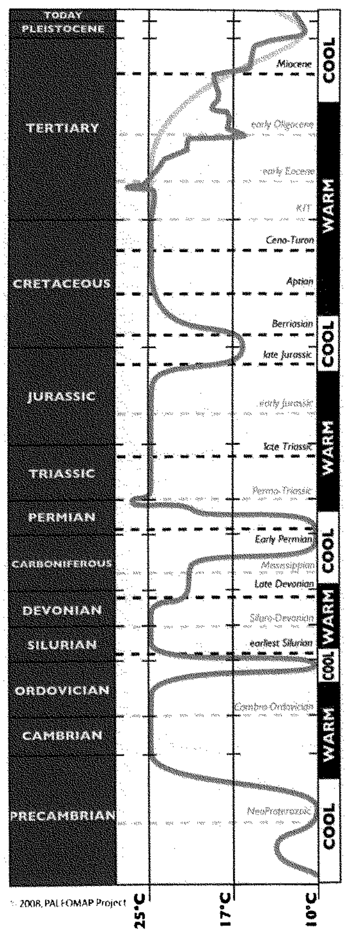
strengthening our efforts to facilitate adaptation. We should focus on building resilience as an approach to protecting ourselves from the risks of climate change as

FIGURE 1
EARTH'S LONG-TERM CLIMATE HISTORY



SOURCE: Christopher R. Scotese, "The Paleomap Project" (Paleomap website, 2002), available at www.scotese.com/climate.htm.

superior to a static approach that singles out only one possible climate influencer (the GHGs) and largely ignores natural climate variability.

This *Outlook* discusses our variable climate and outlines an agenda for building climate resilience that can be implemented immediately and that could offer significant protection for future generations from climate variability.

Our Variable Climate

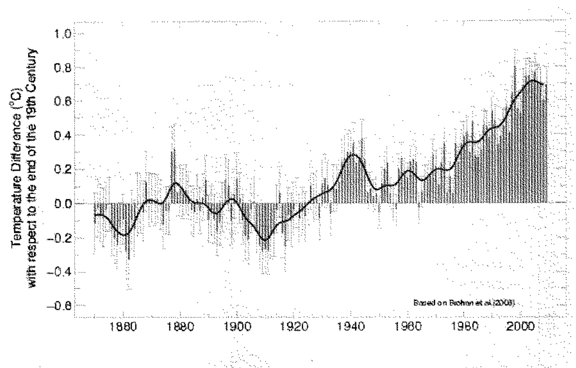
Whether viewed in long- or short-term periods, the Earth's climate history is one of variability, not stasis. Our planet has moved into and out of ice ages and warm periods for as long as we have evidence of historic climate. Figure 1 shows the longest-term picture of climate variability scientists have developed, which uses measured and proxy data. Proxy data consist of estimated temperatures (or other climate variables such as atmospheric moisture) developed by studying what are, in essence, climate fossils: tree rings, ice cores, fossil diatoms, boreholes, fossilized plant leaves, and so on. While proxy data should be considered less reliable than empirical data (meaning that the farther back we look, the more hazy the picture becomes), the scientific paleotemperature reconstructions clearly show the huge variability of the Earth's climate.[1]

The causes of global climate change are a combination of astronomical, geological, oceanographic, geographical, and biological "forcings." Forcings are things that can change the Earth's balance of incoming and outgoing radiation, making the climate warmer or cooler. On the astronomic side of the equation are changes in solar output and cosmic wind, as well as the angle and inclination of the Earth with respect to the sun. On the geological side are variations in volcanic activity or oceanic GHG flux and the response of atmospheric water vapor to climate change. On the biological side of the equation are changes in GHG emissions caused by animals (termites, ruminants, humans) and the production and sequestration of atmospheric carbon by plants and other photosynthetic organisms (such as phytoplankton). On the geographical side, changes in reflectivity of the land through changes in land use and the emission of different amounts of reflective and absorptive particulate pollution can also affect the local climate.

For more recent time periods, scientists have data of slightly better reliability (though there are still problems with data quality). The land temperature record shows that the climate has indeed been changing in

FIGURE 2

GLOBAL AVERAGE NEAR-SURFACE TEMPERATURES, 1850–JUNE 2009



SOURCE: UK Met Office, "Annual Global and Hemispheric Surface Temperatures," HadCrut3 data set, www.metoffice.gov.uk/climatechange/science/monitoring/temperatures.html.

NOTE: The solid bars show the global annual average near-surface temperature anomalies from 1850 to June 2009. The error bars show the 95 percent uncertainty range on the annual averages. The thick line shows the annual values after smoothing with a twenty-one-point binomial filter.

the last century. As figure 2 shows, according to the surface temperature record, there have been five stages of change since 1850, when measurements began. From 1910 to 1940, the Earth experienced a period of warming; from 1940 through 1970, a pronounced cooling; from 1970 to 2000 a pronounced warming; from 2000 to the present, the rate of warming has flattened out and begun to decline.

The last published report of the United Nations IPCC says that "[m]ost of the observed increase in global average temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[2] Others dispute this assertion, arguing that climate models are attributing too much influence to GHGs in the atmosphere.[3]

This *Outlook* does not focus on the question of climate change causality (there are plenty of studies that do), but it is fair to say that scientific understanding of which factors contribute to changes in the Earth's climate is still in a very early stage. Even the experts at the IPCC acknowledge this to be the case. Figure 3, from the Fourth Assessment Report of the IPCC, shows how limited scientific understanding of climate forcing really is. Scientific understanding of potential anthropogenic forcings is often medium-low to low. The same applies to scientific understanding of the nonbiological factors in climate change: articles disputing the role of solar output, cosmic ray flux, ecological GHG contributions, and responses are published on an ongoing basis.[4] From a policy perspective, the important policy question is less about the *cause* of climate variability than about the best response to climate variability, whether manmade or natural.

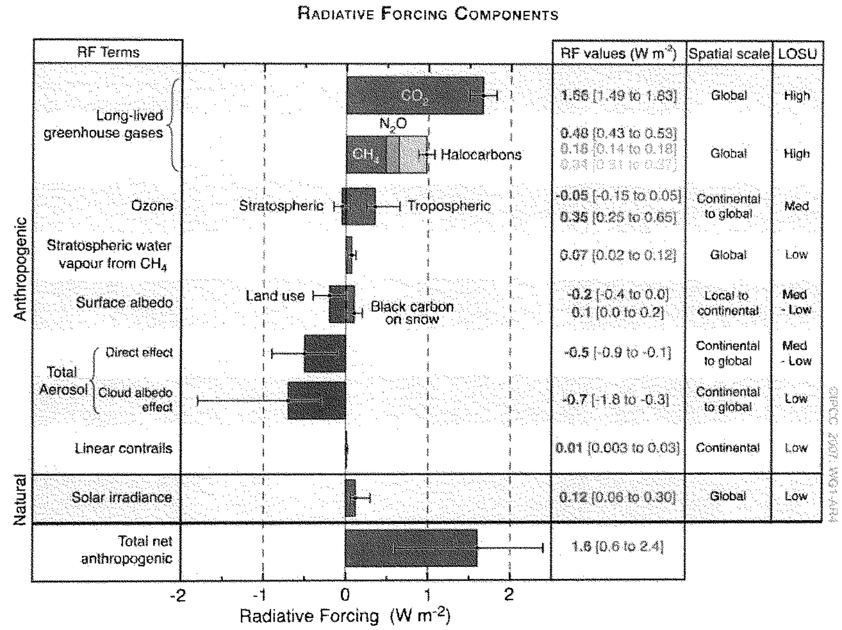
What Is Better, Climate Resilience or Climate Stasis?

In general, the mainstream response to the issue of climate change has been reactive, pessimistic, authoritarian, and resistant to change. Those alarmed about a changing climate would stand athwart the stream of climate history and cry "stop, enough!" Rather than working to cease human influence on climate, they want to find a way to make the climate stand still. This focus on creating climate stasis has led to policy proposals that would have been laughed at or dismissed as wacky conspiracy theories in the 1980s. But mainstream anti–climate change activists are proposing nothing less than the establishment of global weather control through energy rationing, regulations, and taxes, all managed by a global bureaucracy with a goal of leading humanity into a future that will become smaller, more costly, and less dynamic over time. Environmental groups, along with organizations like the United Nations IPCC, are calling for nothing less than imposing climate stasis on a chaotic system.

Consider the climate bill now before Congress: the Waxman-Markey *American Climate and Energy Security Act*. Waxman-Markey sets the ambitious target of reducing total U.S. GHG emissions by 83 percent below 2005 levels by the year 2050 (with intermediate benchmarks at 2020 and 2030). Thus, the cap and the allowances sold pursuant to it will be lowered from a peak of 5.4 billion tons in 2016 to just a little over 1 billion tons in 2050. As my colleague Steven F. Hayward and I have pointed out elsewhere, these targets are absurd.[5] From Department of Energy historical statistics

Figure 3

Global Mean Radiative Forcings, with Levels of Scientific Understanding



Source: IPCC, "2007: Summary for Policymakers," *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (New York and Cambridge: Cambridge University Press, 2007), 4, available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf (accessed September 28, 2009).

Note: Global average radiative forcing estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness.

on energy consumption, it is possible to estimate that the United States last emitted 1 billion tons in the year 1910, when the nation's population was only 92 million people, per-capita income (in 2008 dollars) was only $6,196, and total GDP (also in 2008 dollars) was about $572 billion—about one-twenty-fifth the size of the U.S. economy today. By the year 2050, however, the United States is expected to have a population of 420 million, according to Census Bureau projections—more than four times the population of 1910. In order to reach the 83 percent reduction target, per-capita carbon dioxide (CO_2) emissions will have to be no more than 2.4 tons per person—only one-quarter the level of per-capita emissions in 1910.

When did the United States last experience per-capita CO_2 emissions of only 2.4 tons? From the limited historical data available, it appears that this was about 1875. In 1875, the nation's GDP (in 2008 dollars) was $147 billion, per-capita income (in 2008 dollars) was $3,300, and the population was only 45 million.[6]

My colleague Kevin A. Hassett, Hayward, and I have also written elsewhere about the problems with cap-and-trade and suggested that a revenue-neutral carbon tax would be preferable,[7] but that, too, represents an effort to impose stasis on a dynamic system simply using more efficient means. A carbon tax is, to be sure, vastly superior to a cap-and-trade system, but there are doubts that it is politically possible to enact one in a way that is actually revenue-neutral and is not abused by politicians who will look to tax those they dislike and rebate the taxes to groups they favor, namely, those that are most inclined to vote for their party.

A more forward-looking, optimistic, and free-market approach to the risks of climate variability accepts that the climate has been, is, and will be variable; focuses on the risks of variability; and looks for ways to build resilience in the face of that change, regardless of cause.

FIGURE 4
APPROPRIATE STRATEGIES FOR DIFFERENT STATES OF KNOWLEDGE

Knowledge of the nature and scope of risks and future conditions	Amount of knowledge about intervention measures: Small	Amount of knowledge about intervention measures: Great
High	More resilience, less interception	Interception
Low	Resilience	More resilience, less interception

SOURCE: Adapted from Aaron Wildavsky, *Searching for Safety* (New Brunswick, NJ: Transaction Publishers, 1988), 122.

Aaron Wildavsky's Resilience Paradigm

Aaron Wildavsky, one of the great policy analysts of the late twentieth century, wrote extensively about the benefits of resilient social institutions. Wildavsky observed that possible risk-reduction interventions lie along a spectrum from resilient to interceptive. Resilient approaches maximize our ability to cope with risk by maintaining a dynamic, market-based, knowledge-building strategy. Interceptive interventions emphasize specific risk-reduction efforts that require certain specific actions and prohibit or restrict others.[8] But how do we decide, for a given risk such as climate change, whether an interceptive approach is more likely to provide greater safety than a resilient approach?

Wildavsky demonstrated that uncertainties about the likelihood or extent of any given risk and about the effectiveness of any intervention constrain risk-reduction decisions.[9] Figure 4 shows how uncertainties about the nature and scope of a risk and uncertainties about intervention measures and their effects constrain strategy selection, favoring certain approaches over others.

Employing both theory and empirical observation, Wildavsky observed that a strategy of interception is likely to be successful only in situations of truly excellent information. So, for example, for a power plant owner who knows that a particular part is going to burn out every 150 days, an interception strategy of replacing the part every 149 days to prevent the risk is likely cost-effective. But where less information exists, more resilient strategies are likely to succeed because interception will be either infeasible or expensive in such situations. If a power plant had eight thousand critical pieces of equipment that would create a fire upon failure, but the plant owner did not know the failure rates of each piece, trying to intercept the risk by replacing pieces before they failed would be enormously costly. Further, trying to have backup systems on all eight thousand pieces would be technologically difficult and probably not financially feasible. Instead, a strategy of resilience, such as implementing a sophisticated fire-response system, is more likely to be a feasible and efficient way of dealing with this risk.

In the case of climate change, our knowledge of the nature and scope of risks and future conditions is low, and our knowledge about how to intervene to head off specific risks is small. This suggests that contrary to current policy approaches that focus on mitigating GHG emissions largely to the exclusion of everything else, resilience should be considered the default climate strategy. As Wildavsky observed:

- Resilient systems build knowledge through research and build safety through efficient use of resources, enhancing the ability to respond to and reduce risks over time.

- Resilient approaches optimize use of local knowledge of specific and particular circumstances. Since resources are retained by individuals and firms in the social and economic system, people will instinctively reduce risks as they perceive them.

- Resilient approaches create spillover knowledge by building knowledge at local levels that can then be brought into play in other areas. Research is a natural part of resilient systems.[10]

Wildavsky illustrates these characteristics, drawing from the work of systems ecologists Kenneth E. F. Watt and Paul Craig. In one example, Wildavsky explains why a market-based system is more stable and, therefore, safer: the complexity and intricate nature of negative and positive feedback as conveyed through a market is a powerful stabilizing force whether that market is financial or involves the way energy is distributed through an ecosystem. Natural systems exhibit this complexity and rich feedback milieu, but so do economic systems:

> Systems of great complexity, with stability maintained by a lot of fast acting negative feedback loops are complex economies, with prices responding freely to trends in supply and demand. In such circumstances, we see very rapid introduction of new products, or replacement of old by new products.[11]

In yet another example, Wildavsky points out that ecological studies present cautionary findings with regard to poor specific risk-reduction investments:

> We are specifically concerned with stability of the entire system in contradistinction to stability of each component of the system. That is, we understand that in biological, economic, or any other kind of systems, the former can be maintained at the expense of the latter. Putting this differently, if the goal adopted is to preserve stability of particular system components, the ultimate consequence can be decreased stability in the entire system.[12]

To a large extent, the resilience option is the complete opposite of the climate-stasis approach: it focuses on decentralization, deregulation, and freeing markets to maximize resilience.

Managing Risks with Resilience-Building Policies

A vast range of risks has been discussed in the context of climate change, from flood to drought, threatened food supplies, more deadly insect-borne diseases, higher heat-related deaths, rising sea levels, and so forth. The risks discussed in this *Outlook* are not future probabilities based on empirical evidence and extrapolation. Rather, they derive from computer models of potential future change and are, therefore, not to be taken as known threats but rather as hypothesized threats made using relatively primitive modeling technology subject to the garbage-in, garbage-out problem typical of the breed. The risks are discussed here with that limitation in mind, as potential risks, without any measure of probability attached. Several approaches economists and policy analysts have identified could help increase social resilience to such risks.

> Contrary to current policy approaches that focus on mitigating GHG emissions largely to the exclusion of everything else, resilience should be considered the default climate strategy.

Eliminate Risk Subsidies. Predicted damages associated with sea levels and storms are high because of the popularity of such locales for high-density business and upscale residential development. As a result, damages from extreme coastal weather events have been hugely expensive. The damages from Hurricane Katrina, for example, reached over $150 billion.[13] The question, however, is why was there so much value that was so badly protected against completely predictable events? Levees and sea walls were underdesigned. Many houses and businesses were not insured against flood damage. As Charles Perrow observes in *Our Next Catastrophe*, "Even in areas known to be hazardous, only about 20 percent of homeowners purchase flood insurance, and less than 50 percent of businesses purchase flood and earthquake insurance in risky areas."[14]

The answer to that question lies, at least in part, in the presumed role of state and federal governments as the insurer of last resort. People know that in the event of a disaster, even if uninsured, the Federal Emergency Management Agency will give grants to let people recover from natural disasters such as hurricanes, floods, and storm surges. Without such assurances, we can assume that many people would be unwilling to face the risk of living in coastal areas that could be flooded by rising sea levels and would relocate to higher ground. Capital needed for businesses would also avoid areas of high risk due to sea-level rise, preventing further siting of high-value structures in vulnerable areas.

As researchers at the Wharton Risk Center observe:

> Highly subsidized premiums or premiums artificially compressed by regulations, without clear communication on the actual risk facing individuals and businesses, encourage development of hazard-prone areas in ways that are costly to both the individuals who locate there (when the disaster strikes) as well as others who are likely to incur some of the costs of bailing out victims following the next disaster (either at a state level through ex post [facto] residual market assessments or through federal taxes in the case of federal relief or tax breaks).[15]

Similarly, the CATO Institute points out:

> Government-provided programs for crop insurance and flood insurance, as well as other interventions in private disaster insurance markets, often are justified as necessary to overcome the failure of private markets to offer adequate and affordable disaster insurance. Defenders of government insurance programs claim that they reduce dependence on "free" disaster assistance and promore efficient risk management by property owners and farmers.
>
> But government policies are the cause of, not the cure for, the limited supply and narrow scope of private-sector disaster insurance. Demand for private coverage is low in part because of the availability of disaster assistance, which substitutes for both public and private insurance. Moreover, a government that cannot say no to generous disaster assistance is unlikely to implement an insurance program with strong incentives for risk management.
>
> The subsidized rates and limited underwriting and risk classification of federal government insurance programs aggravate adverse selection, discourage efficient risk management, and crowd out market-based alternarives.
>
> Federal tax policy reduces supply by substantially increasing insurers' costs of holding capital to cover very large but infrequent losses. State governments also intrude on insurance markets by capping rates, mandating supply of particular types of insurance, and creating state pools to provide catastrophe insurance or reinsurance coverage at subsidized rates. By reducing both the supply and demand sides of private insurance protection, government intervention leads to greater reliance on politically controlled disaster assistance and higher costs for taxpayers.[16]

Perrow makes the case that this is no better at the state level:

> State-mandated pools have been established to serve as a market of last resort for those unable to get insurance, but the premiums are low and thus these have the perverse effect of subsidizing those who choose to live in risky areas and imposing excess costs on people living elsewhere. In addition, the private insurers are liable for the net losses of these pools, on a market-share basis. The more insurance they sell, the larger their liability for the uninsured. Naturally, they are inclined to stop writing policies where there may be catastrophic losses (hurricanes in Florida and earthquakes in California). The Florida and California coastlines are very desirable places to live and their populations have grown rapidly, but these handsome lifestyles are subsidized by residents living in the less desirable inland areas in the state, and, to some limited extent, by everyone in the nation.[17]

If risk subsidies cannot be abolished entirely, at the very least, insurance companies should charge risk-based premiums. As Wharton researchers explain:

> Insurance premiums (whether public or private coverage) should, to the extent possible, reflect the underlying risk associated with the events against which coverage is bought in order to provide a clear signal to individuals and businesses of the dangers they face when locating in hazard-prone areas and [to] encourage them to engage in cost-effective mitigation measures to reduce their vulnerability to disasters.[18]

Privatize Infrastructure. Climate change could also pose a challenge for coastal or low-lying roadways, water-treatment facilities facing increased rainfall intensity, energy utilities facing increased summertime electricity demand, and so on. Governments are quite good at building infrastructure. After all, what politician does not enjoy a ribbon cutting ceremony for some new element of name-bearing infrastructure? But governments are dismal at maintaining infrastructure, as they generally fail to establish a revenue stream to maintain a system that provides feedback about whether a particular road should be raised or a water-treatment facility expanded or a power capability increased. A solution to these problems, as well as a potential source of revenue for cash-strapped state and municipal governments, is the privatization of infrastructure. While a few poorly executed privatization efforts have tarnished the name, the baby should not be thrown out with the bath water; privatization offers a host of benefits. A great deal of research on privatization in developing and developed countries demonstrates that, on the whole, privatization shows considerably more benefit than risk.

It has long been known that certain types of risk are not suited to attempted prevention but instead must be met with the resilience needed to live with the risk. Climate change is one such risk that is virtually impossible to prevent.

In "An Assessment of Privatization," Sunita Kikeri and John Nellis conclude that "[i]n infrastructure sectors, privatization improves welfare, a broader and crucial objective when it is accompanied by proper policy and regulatory frameworks." Further, they observe that "ownership change in productive firms, as well as private investment in less than full ownership capacity, usually improves the financial situation of the firm and the fiscal position of selling government, increases returns to shareholders, and in the right policy circumstances, generates significant welfare benefits as well."[19] Private owners of infrastructure have a lot of investment tied up in getting a long-run stream of revenue from the infrastructure. Ensuring that future changes in climare do not disrupt that long-run cash flow is critical to their current financial performance.

Roadways. If roads are privately owned and tolled, road operators have a revenue stream to tap in order to raise, resurface, or recontour roadways to adapt to climate changes. If costs of such adaptation are high, tolls will rise, and at some point, an economic decision will occur about whether a road should be maintained or whether some alternate route should be developed. In some cases, people may indeed find their transportation options so limited that they must move away to a place with a less fragile climate. One can imagine something like this for some coastal roadways where there are no easy alternate routes, but it would probably be a fairly rare outcome. Still, if such situations did develop, this is a desirable outcome, as it is both economically efficient and reduces the likely cost of climate-related damages to structures.

Electricity Supply. As long as governments distort the prices consumers pay for energy with subsidies, fuel mandates, renewable power mandates, and the like, electricity markets cannot effectively adapt to changing climatic conditions. If electricity markets were fully deregulated, and if full costs were passed onto consumers, price signals would be created for the electricity provider in terms of expanding or decreasing capacity and for the consumer in terms of the real cost of living in an environment subject to energy-consuming heat waves (or cold snaps). Privatization would create incentives for electricity conservation and for the acquisition of energy-efficient appliances and devices without any need for specific governmental efficiency standards. Further, electric companies would be driven to connect with one another to ensure reliability to their customers rather than doing the minimum possible to satisfy regulators.

Water Supply. Full pricing of water and full privatization of the water supply, drinking water plants, and wastewater treatment plants would ameliorate many climatic risks incrementally over time, including flooding, seawater intrusion, and coastal and river pollution from storm runoff. Charging the full price for water, from supply to disposal, would create a price signal for consumers regarding the real risks they face living in hydrologically sensitive areas and create incentives for conservation while producing a revenue stream to allow for expanded capability or the securing of alternative supplies. At some point, again, high prices could simply lead people to move away from areas that are hydrologically costly, such as cities dependent on a single winter snow pack that shrinks or a single major river that suffers reduced flow.

Flooding. What is not achieved by removing insurance subsidies in flood-prone areas can be managed through the creation of privately administered hydrologic utilities, which would be financed by flood-protection fees charged to residents of flood-prone areas. Again, such a system creates a price signal that can show when it is and when it is not efficient to raise the height of a levee, for example, or to expand permeable surfacing requirements in development. The cost of paying for such activities would send the consumer a signal about the true cost of living in flood-prone areas and would ultimately lead those who could not afford to fully finance their level of risk to relocate to safer areas.

Trust in Resilience, but Tie Up Your Camel

In the event that climate change does tend toward higher estimates put forward by the United Nations and other groups, it is reasonable to consider insurance options that might help deal with such climate changes. Such options might include government investment in geoengineering research, investment in research and development to advance technologies allowing the removal of GHGs from the atmosphere, and possibly the creation of a climate adaptation fund to be used when state and local governments find themselves unable to cope with a given climate change, or even to compensate others should it ultimately be shown that U.S. emissions of GHGs have caused harm to other countries or the property of other individuals.

It has long been known that certain types of risk are not suited to attempted prevention but instead must be met with the resilience needed to live with the risk. Climate change is one such risk that is, as the world is increasingly observing, virtually impossible to prevent, whether it is manmade or natural.

As efforts to mitigate GHGs fail around the world, it is long past time to broaden the tools available to us in order to make our society resilient to climate risk. Rather than remain largely focused on the quixotic effort to reduce GHG emissions or to stand athwart the stream of climate and shout "stop, enough!" we should shift the majority of our policymaking attention to an agenda of resilience building and adaptation, two areas with which governments particularly struggle. Plan B for climate resilience should consist of an aggressive program of resilience building through the elimination of risk subsidies and the privatization of infrastructure. Other subsidies and regulations that make the overall economy more brittle in the face of climate change would also be ripe targets for removal, such as those which permeate energy and water markets.

The author would like to acknowledge the assistance of Dharana Rijal in producing this Outlook.

Notes

1. Christopher R. Scotese, "The Paleomap Project" (Paleomap website, 2002), available at www.scotese.com/climate.htm (accessed September 23, 2009).

2. International Panel on Climate Change, "2007: Summary for Policymakers," *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (New York and Cambridge: Cambridge University Press, 2007), 10, available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf (accessed September 23, 2009).

3. Richard S. Lindzen and Yong-Sang Choi, "On the Determination of Climate Feedbacks from ERBE Data," *Geophysical Research Letters* 36, no. 16 (August 2009); and Roy W. Spencer and William D. Braswell, "Potential Biases in Feedback Diagnosis from Observations Data: A Simple Model Demonstration," *Journal of Climate* 21 (November 2008): 5624–28.

4. Nir J. Shaviv and Ján Veizer, "Celestial Driver of Phanerozoic Climate?" *GSA Today* (July 2003), available at www.gsajournals.org/archive/1052-5173/13/7/pdf/i1052-5173-13-7-4.pdf (accessed September 24, 2009). See also Judith L. Lean and David H. Rind, "How Will Earth's Temperature Change in Future Decades?" *Geophysical Research Letters* 36 (August 2009), available at http://pubs.giss.nasa.gov/docs/2009/2009_Lean_Rind.pdf (accessed September 24, 2009).

5. Steven F. Hayward and Kenneth P. Green, "Waxman-Markey: An Exercise in Unreality," AEI *Energy and Environment Outlook*, no. 3 (July 2009), available at www.aei.org/outlook/100057.

6. It is possible that per-capita CO_2 emissions were never this low even before the advent of widespread use of fossil fuels: wood burning by Americans in the nineteenth century may have produced more than 2.4 tons of CO_2 per capita. Much depends on the emissions coefficient for wood burning and how, since wood is biomass rather than a fossil fuel, reforestation is credited in carbon accounting. In 1875, burning wood generated twice as much energy as fossil fuels.

7. Kenneth P. Green, Steven F. Hayward, and Kevin A. Hassett, "Climate Change: Caps vs. Taxes," AEI *Environment and Energy Outlook*, no. 2 (June 2007), available at www.aei.org/outlook/26286.

8. Aaron Wildavsky, *Searching for Safety* (New Brunswick, NJ: Transaction Publishers, 1988). Wildavsky used the terms "resilience" and "anticipation" rather than "resilience" and "interception." In adapting Wildavsky's framework to more recent risk-related issues, I have chosen to use "interception" because it corresponds better to common perceptions of how risk regulations work.

9. Ibid., 122.

10. Ibid.

11. Ibid., 114.

12. Ibid., 112.

13. Mark L. Burton and Michael J. Hicks, *Hurricane Katrina, Preliminary Estimates of Commercial and Public Sector Damages* (Huntington, WV: Marshall University Center for Business and Economic Research, September 2005), available at www.marshall.edu/cber/research/katrina/Katrina-Estimates.pdf (accessed September 24, 2009).

14. Charles Perrow, *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters* (Princeton, NJ: Princeton University Press, 2007), 37–38.

15. Erwann O. Michel-Kerjan, "Disasters and Public Policy: Can Market Lessons Help Address Government Failures?" *The National Tax Journal* (January 2007), available at http://opim.wharton.upenn.edu/risk/library/07-04.pdf (accessed September 24, 2009).

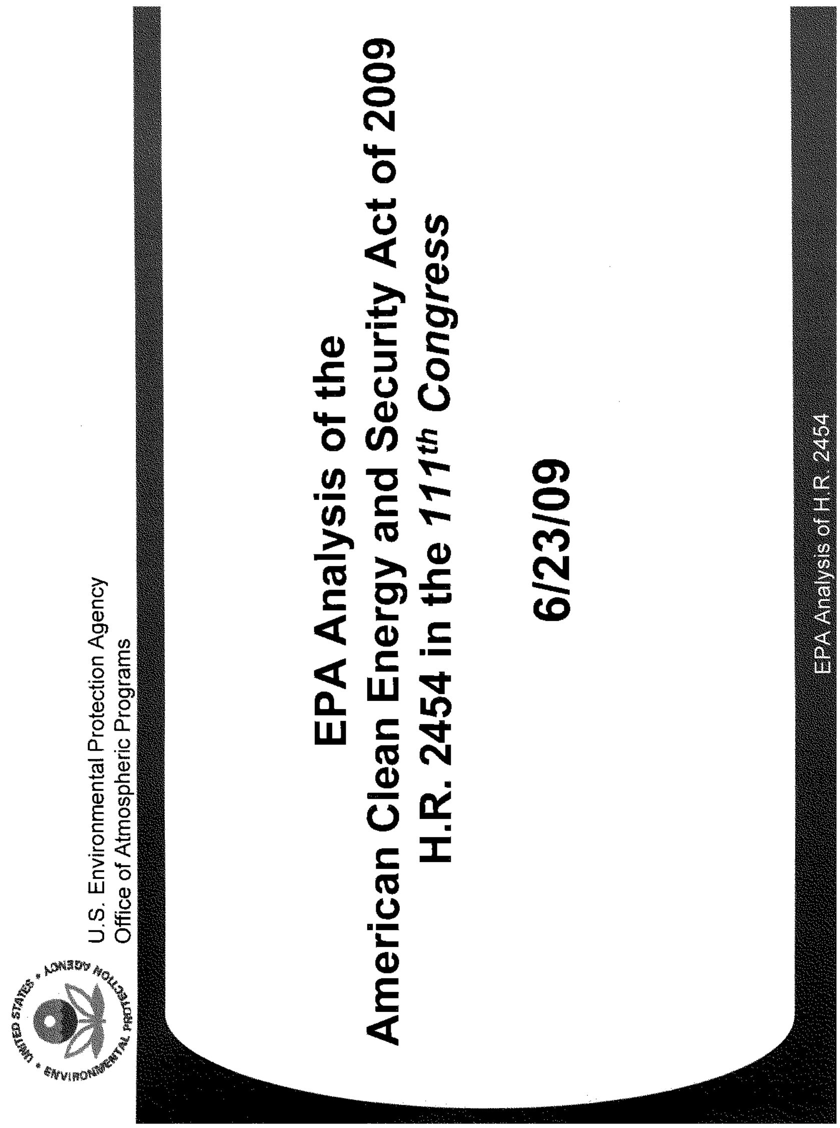
16. Cato Institute, "Disaster Assistance and Government Insurance," *Cato Handbook for Congress: Policy Recommendations for the 107th Congress* (Washington, DC: Cato Institute, 2003): 431–39, available at www.cato.org/pubs/handbook/hb107/hb107-40.pdf (accessed September 24, 2009).

17. Charles Perrow, *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters*, 38–39.

18. Erwann O. Michel-Kerjan, "Disasters and Public Policy: Can Market Lessons Help Address Government Failures?"

19. Sunita Kikeri and John Nellis, "An Assessment of Privatization," *The World Bank Research Observer* 19, no. 1 (Spring 2004).

[Additional material submitted for the record follows:]



Request for Analysis

HENRY A. WAXMAN, CALIFORNIA
CHAIRMAN

JOE BARTON, TEXAS
RANKING MEMBER

ONE HUNDRED ELEVENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6115

Majority (202) 225-2927
Minority (202) 225-3641

May 14, 2009

The Honorable Lisa Jackson
Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington DC, 20460

Dear Administrator Jackson:

Passage of comprehensive clean energy legislation is one of the top priorities of the Committee on Energy and Commerce. We plan to report a bill from committee prior to the Memorial Day recess. This legislation will reflect the Committee's work product and may differ significantly from the discussion draft circulated in March. To facilitate Congressional consideration of the legislation, we are requesting additional technical assistance and modeling results from the Environmental Protection Agency (EPA). EPA's analysis of the committee passed legislation will prove useful to us and other members of the House as we move forward.

We ask that EPA begin this process by meeting with our committee staff in advance of committee passage. Please call Alexandra Teitz, Lorie Schmidt or Joel Beauvais at (202) 225-4407.

Sincerely,

Henry A. Waxman
Chairman

Edward J. Markey
Chairman
Subcommittee on Energy and Environment

- On March 31, 2009, the House Energy and Commerce Committee released the Waxman-Markey Discussion Draft of the American Clean Energy and Security Act of 2009.
- On April 20, 2009, EPA released a preliminary analysis of the Waxman-Markey Discussion Draft.
- On May 14, 2009, the House Energy and Commerce Committee Chairman Waxman and Energy and Environment Subcommittee Chairman Markey requested that EPA estimate the economic impacts of the Committee-reported bill.
- On May 21, 2009, the American Clean Energy and Security Act of 2009 (H.R. 2454) was passed by the House Energy and Commerce Committee.
- This document represents EPA's analysis of the American Clean Energy and Security Act of 2009 (H.R. 2454).

The analysis was conducted by EPA's Office of Atmospheric Programs.

Contact: Allen A. Fawcett
Tel: 202-343-9436
Email: fawcett.allen@epa.gov

This analysis is available online at:
www.epa.gov/climatechange/economics/economicanalyses.html

Major Findings

- The American Clean Energy and Security Act of 2009 (H.R. 2454):
  - Establishes an economy wide cap & trade program.
  - Creates other incentives and standards for increasing energy efficiency and low-carbon energy consumption.
- The analysis focuses on the economy wide cap & trade program, the energy efficiency provisions, and the competitiveness provisions.
  - Sensitivity analysis conducted for:
    - H.R. 2454 without Energy Efficiency Provisions
    - H.R. 2454 without Output Based Rebates
    - H.R. 2454 with Reference Level Nuclear
    - H.R. 2454 with No International Offsets
  - Several provisions outside of the cap & trade program are not modeled in this analysis (e.g. lighting standards are not in the analysis, and the renewable electricity standard is not included in economy-wide modeling but is modeled as a sensitivity in power sector analysis).
  - See Appendix 1 for a full description of the bill and which provisions are modeled in this analysis.

Major Findings

- H.R. 2454 transforms the structure of energy production and consumption.
  - Increased energy efficiency and reduced demand for energy resulting from the policy mean that energy consumption levels that would be reached in 2015 without the policy are not reached until 2040 with the policy.
  - The share of low- or zero-carbon primary energy (including nuclear, renewables, and CCS) rises substantially under the policy to 18% of primary energy by 2020, 26% by 2030, and to 38% by 2050, whereas without the policy the share would remain steady at 14%. Increased energy efficiency and reduced energy demand simultaneously reduces primary energy needs by 7% in 2020, 10% in 2030, and 12% in 2050.
  - Electric power supply and use, and offsets represent the largest sources of emissions abatement.

- Allowance prices are less than EPA's previous analysis of the Waxman-Markey discussion draft, \$13 per metric ton CO_2 equivalent (tCO_2e) in 2015 and \$16/tCO_2e in 2020 in the core scenario.
  - This is primarily driven by the looser 2020 cap and the expanded amount of international offsets allowed.
  - Across all scenarios modeled without constraints on international offsets, the allowance price ranges from \$13 to \$15 per ton CO_2 equivalents (tCO_2e) in 2015 and from \$16 to \$19 / tCO_2e in 2020.
  - Across all scenarios modeled that vary constraints on international offsets, the allowance price ranges from \$13 to \$24 per ton CO_2 equivalents (tCO_2e) in 2015 and from \$16 to \$30 / tCO_2e in 2020.

- Offsets have a strong impact on cost containment.
  - The annual limit on domestic offsets is never reached.
  - While the limits on the usage of international offsets (accounting for the extra international offsets allowed when the domestic limit is not met) are not reached, the usage of international offsets averages over 1 billion tCO_2e each year.
  - Without international offsets, the allowance price would increase 89 percent relative to the core policy scenario. If international offsets were not available for only the first 10 years, the allowance price would increase by just 3%. If extra international offsets could not be used when the domestic offset usage was below one billion tCO_2e, then the allowance price would increase 11%.

Major Findings

- The cap & trade policy has a relatively modest impact on U.S. consumers assuming the bulk of revenues from the program are returned to households.
  - Average household consumption is reduced by 0.03-0.08% in 2015 and 0.10-0.11% in 2020 and 0.31-0.30% in 2030, relative to the no policy case.
  - Average household consumption will increase by 8-10% between 2010 and 2015 and 15-19% between 2010 and 2020 in the H.R. 2454 scenario.
  - In comparison to the baseline, the 5 and 10 year average household consumption growth under the policy is only 0.1 percentage points lower for 2015 and 2020.
  - Average annual household consumption is estimated to decline by $80 to $111 dollars per year* relative to the no policy case. This represents 0.1 to 0.2 percent of household consumption.
  - These costs include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital. Cost estimates also reflect the value of some of the emissions allowances returned to households, which offsets much of the cap & trade program's effect on household consumption. The cost estimates do not account for the benefits of avoiding the effects of climate change.
  - A policy that failed to return revenues from the program to consumers would lead to substantially larger losses in consumption.
- While this analysis contains a set of scenarios that cover some of the important uncertainties when modeling the economic impacts of a comprehensive climate policy, there are still remaining uncertainties that could significantly affect the results.

*Annual net present value cost per household (discount rate = 5%) averaged over 2010-2050 under the core scenario

Contents

H.R. 2454

Bill Summary

- Title III of the American Clean Energy and Security Act of 2009 (H.R. 2454) establishes a cap & trade system for greenhouse gas emissions.
  - The cap gradually reduces covered greenhouse gas emissions to 17 percent below 2005 levels by 2020, and 83 percent below 2005 levels by 2050.
  - Banking of allowances is unlimited, a two-year compliance period allows borrowing from one year ahead without penalty, limited borrowing from two to five years ahead.
  - 1-3% of allowances in each year will be set aside in a Strategic Allowance Reserve, from which allowances will be auctioned 4 times each year. Up to 20% of a covered entity's emissions may be purchased from the reserve in a given year.
  - Offsets are limited to 2,000 million metric tons CO_2 equivalent ($MtCO_2e$) per year.
  - Supplemental emissions reductions from reduced deforestation through allowance set-asides.
- Titles I & II of H.R. 2454 deal with clean energy and energy efficiency, and among other things establish a renewable electricity standard, and energy efficiency programs and standards for buildings, lighting, appliances.
  - Not all provisions in Titles I & II are explicitly modeled in this analysis.
- Title IV addresses competitiveness issues and the transition to a clean energy economy.
  - Creates an output-based allowance allocation mechanism based on H.R. 7146 (Inslee-Doyle bill).
  - Allows for the implementation of an international reserve allowance requirement.
  - The output-based allowance allocation mechanism is included in this analysis, but not in all scenarios. The rest of Title IV is not included in this analysis.
- See Appendix 1 for a discussion of the bill, and which provisions are modeled here.

Analytical Scenarios

EPA analyzed 7 different scenarios in this preliminary report. A full description of all scenarios is available in Appendix 1. The assumptions about other domestic and international policies that affect the results of this analysis do not necessarily reflect EPA's views on likely future actions. These scenarios do not account for the American Recovery and Reinvestment Act, which could further advance the deployment of clean energy technologies.

1) **EPA 2009 Reference Scenario**
   - This reference scenario is benchmarked to the AEO 2009 forecast (March release) and includes EISA but not ARRA.
     - Does not include any additional domestic or international climate policies or measures to reduce international GHG emissions
     - For domestic projections, benchmarked to AEO 2009 (March release) without the American Recovery and Reinvestment Act of 2009 (ARRA).
     - Does not include the recently announced federal greenhouse gas and fuel economy program for passenger cars, light-duty trucks, and medium-duty passenger vehicles.
     - For international projections, used CCSP Synthesis and Assessment Report 2.1 A MiniCAM Reference.
2) **H.R. 2454 Scenario**
   - This core policy scenario models the cap-and-trade program established in Title III of H.R. 2454.
     - The strategic allowance reserve is not modeled (i.e., these allowances are assumed to be available for use and not held in reserve).
   - Provisions explicitly modeled in this scenario:
     - CCS bonus allowances
     - EE provisions (allowance allocations, building energy efficiency codes, and energy efficiency standard component of CERES).
     - Output-based rebates (Inslee-Doyle)
     - Allocations to electricity local distribution companies (LDCs) (used to lower electricity prices)
   - Widespread international actions by developed and developing countries over the modeled time period. International policy assumptions are based on those used in the 2007 MIT report, "Assessment of U.S. Cap-and-Trade Proposals."
     - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling gradually from the simulated Kyoto emissions levels in 2012 to 50% below 1990 in 2050.
     - Group 2 countries (rest of world) adopt a policy beginning in 2025 that returns and holds them at year 2015 emissions levels through 2034, and then returns and maintains them at 2000 emissions levels from 2035 to 2050.
3) **H.R. 2454 Scenario without Energy Efficiency Provisions**
4) **H.R. 2454 Scenario without Output-Based Rebates**
5) **H.R. 2454 Scenario with Reference Nuclear**
6) **H.R. 2454 Scenario without Energy Efficiency, Output-Based Rebates, or LDC Allocations***
7) **H.R. 2454 Scenario with No International Offsets**

* **Scenario 6 is most directly comparable to the core scenario of EPA's preliminary analysis of the Waxman-Markey discussion draft, which did not include energy efficiency provisions, output-based rebates, or LDC allocations.**

Key Uncertainties

- There are many uncertainties that affect the economic impacts of H.R. 2454.
- This analysis contains a set of scenarios that cover some of the important uncertainties.*
  - The degree to which new nuclear power is technically and politically feasible.
  - The availability of international offset projects.
  - The amount of GHG emissions reductions achieved by the energy efficiency provisions of H.R. 2454.
  - The impact of output based rebates to energy intensive and trade exposed industries.

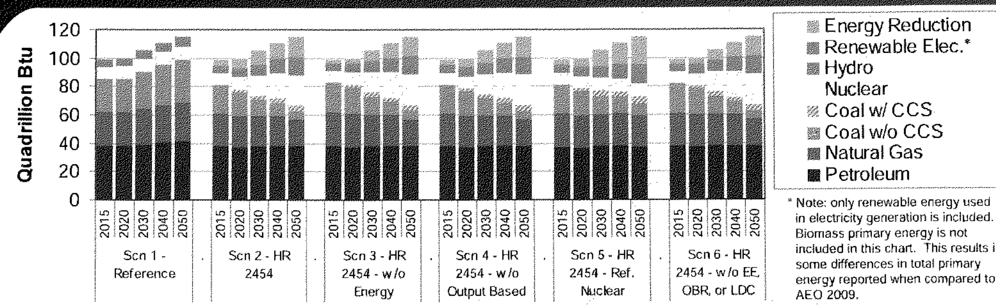
- Additional uncertainties include but are not limited to:
  - The impact of the Strategic Allowance Reserve (e.g., the extent to which it increases banking of allowances in the early years of the program).
  - The distributional consequences of H.R. 2454.
  - The extent and stringency of international actions to reduce GHG emissions by developed and developing countries.
  - The availability and cost of domestic offset projects.
  - The availability and cost of carbon capture and storage technology.
  - Long-run cost of achieving substantial GHG abatement.
    - Note that because of banking, uncertainty in long run abatement costs can have a significant impact on near term prices.
  - The pace of economic and emissions growth in the absence of climate policy.
  - Possible interactions among modeled and non-modeled policies.
  - The impact of the American Recovery and Reinvestment Act of 2009 on the cost of climate policy.
  - The impact of price reducing versus lump sum allocations to local electric distribution companies.
  - The responsiveness of household labor supply to changes in wages and prices (labor supply elasticity).
  - Other parameter uncertainty, particularly substitution elasticities (e.g., the abilities of firms to substitute capital, labor, and materials for energy inputs).

* Note that because of time limitations this analysis does not contain an extensive set of scenarios that would cover some of the additional uncertainties described above.

Economy Wide Impacts: GHG Emissions & Economic Costs

Primary Energy

H.R. 2454 Scenario Comparison (ADAGE)

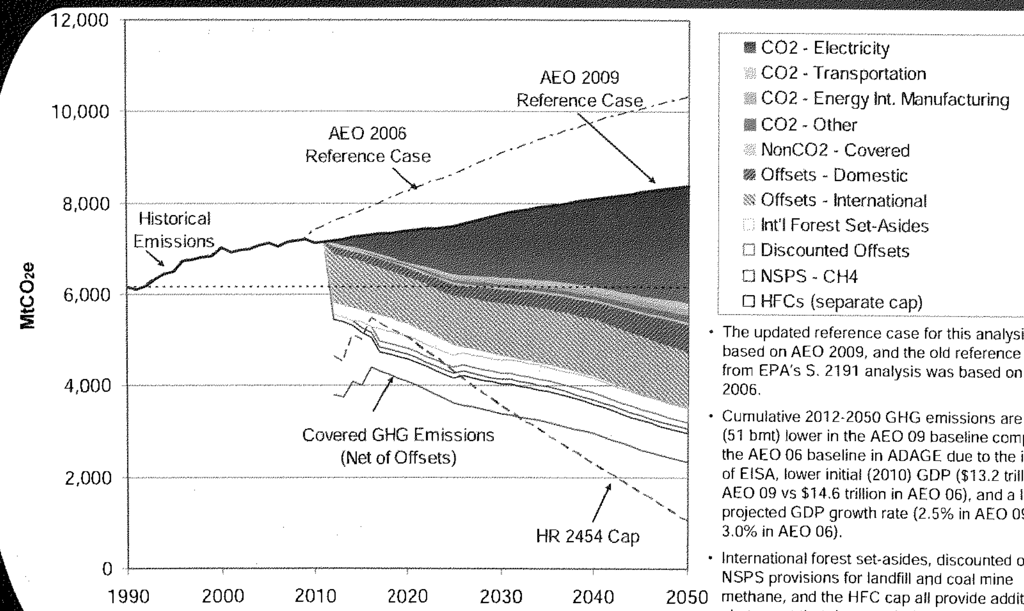


* Note: only renewable energy used in electricity generation is included. Biomass primary energy is not included in this chart. This results in some differences in total primary energy reported when compared to AEO 2009.

- The structure of energy consumption is transformed in the policy scenarios.
- In the reference scenario, primary energy use is 99 quadrillion Btu in 2015, and grows 7% by 2030 and 17% by 2050.
  - In scenario 2, primary energy use falls to 95 and 93 quadrillion Btu in 2015 and 2020 respectively, and rebounds to 2015 reference levels by 2040.
  - In scenario 5 with nuclear power constrained to reference case levels, primary energy use falls to 95 quadrillion Btu in 2015 and to 93 quadrillion Btu in 2020, and slowly rebounds to 95 quadrillion Btu by 2050.
- In the reference case, low- or zero- carbon energy (including nuclear, renewables, and CCS) makes up a steady 14% of total primary energy.
  - In scenario 2, low- or zero- carbon energy makes up 18% of primary energy by 2020, 26% by 2030, and 38% by 2050.
  - In scenario 5 with reference level nuclear, low- or zero- carbon energy makes up18% of primary energy by 2020, 22% by 2030, and 29% by 2050.
- See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used to represent energy efficiency programs.
- Constraints on nuclear power growth are exogenous to the model (nuclear power generation is allowed to increase by ~150% from 782 bill. kWh in 2005 to 2,081 bill. kWh in 2050).
  - The reductions seen in primary energy from coal are somewhat driven by the model's representation of energy efficiency programs and the assumptions about nuclear power.
    - Compared to scenario 2, which includes energy efficiency programs, the reduction in primary energy from coal in scenario 3 without energy efficiency programs is 27% smaller in 2015 and 36% smaller in 2020. (In later years the two scenarios are more similar).
    - Compared to scenario 2, the reduction in primary energy from coal in scenario 5 with reference level nuclear is 18% smaller in 2030 and 17% smaller in 2050.

Total US GHG Emissions & Sources of Abatement

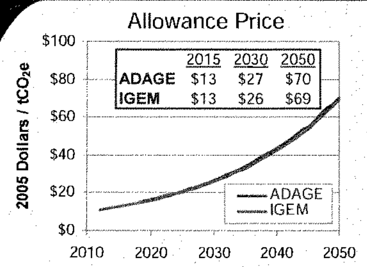
Scenario 1 - Reference & Scenario 2 – H.R. 2454 (ADAGE)

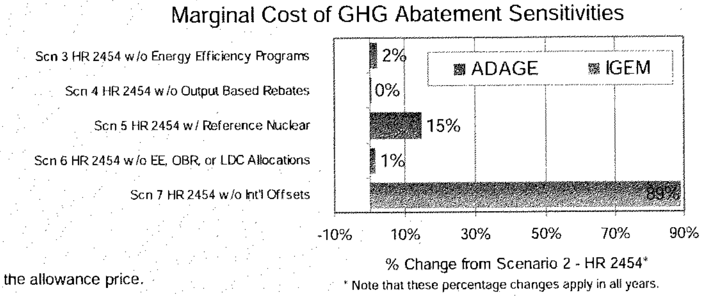


- The updated reference case for this analysis is based on AEO 2009, and the old reference case from EPA's S. 2191 analysis was based on AEO 2006.
- Cumulative 2012-2050 GHG emissions are 14% (51 bmt) lower in the AEO 09 baseline compared to the AEO 06 baseline in ADAGE due to the inclusion of EISA, lower initial (2010) GDP ($13.2 trillion in AEO 09 vs $14.6 trillion in AEO 06), and a lower projected GDP growth rate (2.5% in AEO 09 vs 3.0% in AEO 06).
- International forest set-asides, discounted offsets, NSPS provisions for landfill and coal mine methane, and the HFC cap all provide additional abatement that does not help to meet the main cap.

GHG Allowance Prices & Sensitivities

H.R. 2454 Scenario Comparison

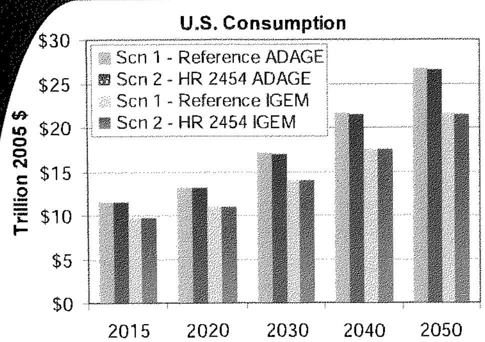


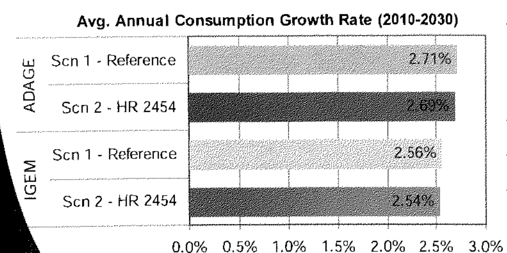


- The marginal cost of GHG abatement is equal to the allowance price.
- Range of 2030 allowance price in *"scenario 2 – HR 2454"* across models is: $26 - $27. This range only reflects differences in the models and does not reflect other scenarios or additional uncertainties discussed elsewhere.
- The range of 2030 allowance prices across all scenarios that allow international offsets is: $26 - $31.
- In scenarios 2, 3, 4, and 6, the limit on international offsets usage is non-binding, and thus the domestic allowance price is equal to the international offset price (after discounting) and the international offset price acts a floor on the allowance price.
  - Because of this, the impact of these sensitivities on allowance prices is muted by the change in the usage of international offsets and the amount of abatement occurring within covered sectors (e.g. a change that would ordinarily lead to lower allowance prices instead would lead to decreased usage of international offsets.)
  - See the 'Offsets Usage & Limits' section below for information on how international offsets usage changes across scenarios.
- Without any international allowances, the allowance price would increase by 89% relative to the core scenario. See 'Offsets Usage & Limits' section below for a discussion of how varying degrees of international offsets availability impacts allowance prices.
- The availability of nuclear and carbon capture and sequestration (CCS) technologies have a significant impact on allowance prices. In particular, restricting nuclear power to reference case levels increases international offsets usage to the limit and results in a 15% increase in allowance prices relative to the core scenario.

Consumption

Scenario 1 – Reference & Scenario 2 – H.R. 2454





ADAGE	2015	2020	2030	2040	2050
Ref. Consumption per Household	$92,202	$99,888	$117,973	$140,233	$164,348
% Change (Scn. 2)	-0.08%	-0.11%	-0.31%	-0.55%	-0.78%
Consumption Loss per Household	-$70	-$105	-$366	-$771	-$1,287
NPV Cost per HH ($)	-$53	-$61	-$132	-$170	-$174

Average Annual NPV cost per Household -$111

IGEM	2015	2020	2030	2040	2050
Ref. Consumption per Household	$75,531	$80,507	$91,686	$105,202	$119,168
% Change (Scn. 2)	-0.03%	-0.10%	-0.30%	-0.55%	-0.76%
Consumption Loss per Household	-$21	-$84	-$277	-$582	-$912
NPV Cost per HH	-$16	-$49	-$99	-$128	-$123

Average Annual NPV cost per Household -$80

- The average annual cost per household is the 2010 through 2050 average of the net present value of the per household consumption loss in "*scenario 2 – H.R. 2454*."
- The costs above include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital, and importantly, the above cost estimates reflect the value of emissions allowances returned lump sum to households, which offsets much of the cap-and-trade program's effect on household consumption. The cost does not include the impacts on leisure.
- This analysis is a cost-effectiveness analysis, not a cost-benefit analysis. As such, the benefits of reducing GHG emissions were not determined in this analysis.
- The $80 - $111 average annual cost per household is the annual cost of achieving the climate benefits that would result from this bill.
- See Appendix 1 for a discussion of consumption accounting differences between ADAGE and IGEM and of composition of GDP.
- See Appendix 5 for a more detailed discussion of the average annual NPV cost per household calculation, and additional consumption cost metrics.

Total Abatement Cost

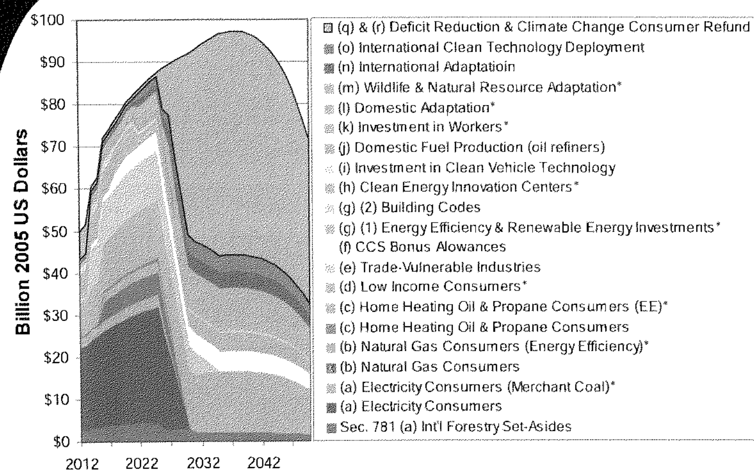
Scenario 2 – H.R. 2454

Table: **Total Abatement Cost Calculations**
Scenario 2 - HR 2454

	2015	2020	2030	2040	2050
Total Allowance Value (Billion 2005 Dollars)					
ADAGE	$62	$79	$94	$99	$73
IGEM	$63	$81	$92	$97	$71
Domestic Covered Abatement (MtCO2e)					
ADAGE	380	808	1,661	2,263	3,028
IGEM	728	1,028	1,421	1,912	2,628
Domestic Offset Abatement (MtCO2e)					
ADAGE	177	186	285	367	599
IGEM	172	176	287	370	643
International Offsets & Set-Asides (MtCO2e before discounting)					
ADAGE	1,340	1,571	1,552	1,632	1,550
IGEM	1,329	1,560	1,456	1,429	1,447
Allowance Price ($/tCO2e)					
ADAGE	$13	$16	$27	$43	$70
IGEM	$13	$16	$26	$42	$69
Offset Price ($/tCO2e)					
ADAGE	$13	$16	$27	$43	$70
IGEM	$13	$16	$26	$42	$69
International Offset/Credit Price ($/tCO2e before discounting)					
ADAGE	$10	$13	$21	$34	$55
IGEM	$10	$13	$21	$34	$55
Domestic Covered Abatement Cost (Billion 2005 Dollars)					
ADAGE	$2	$7	$22	$49	$107
IGEM	$5	$8	$18	$40	$91
Domestic Offset Abatement Cost (Billion 2005 Dollars)					
ADAGE	$1	$2	$4	$8	$21
IGEM	$1	$1	$4	$8	$22
International Offset Payments (Billion 2005 Dollars)					
ADAGE	$13	$20	$32	$55	$86
IGEM	$13	$20	$30	$48	$80
Total Abatement Cost (Billion 2005 Dollars)					
ADAGE	$17	$28	$58	$112	$213
IGEM	$19	$30	$52	$97	$193

- Total allowance value is the value of allowances issued in each year (i.e. allowance price multiplied by the cap level).
- The allowance price is equal to the marginal cost of abatement.
- The offset price is the marginal cost of abatement for uncovered sectors and entities in the U.S. When the limit on offset usage is non-binding, the offsets price is equal to the allowance price.
- The international offset price is the marginal cost of abatement outside of the U.S.
- Domestic covered abatement cost is approximated for each model as the product of domestic covered GHG emissions abatement and the allowance price divided by two.
  - Division by 2 is assumed to represent the fact that most reduction measures are not implemented at the marginal allowance price but at lower prices. In most cases, the relationship between emission reduction and the marginal price is a convex curve – which implies a value larger than 2. The value of 2, used here for simplicity leads to an overestimation of abatement costs.
- Domestic offset abatement cost is approximated for each model as the product of domestic offset abatement and the offset price divided by two.
- International offset payments are calculated for each model as the product of the amount of international offsets purchased and the international credit price.
  - Unlike the abatement costs associated with domestic covered abatement and domestic offsets, there is no need for dividing by two when calculating the costs of international offsets as they are all purchased at the full price of international allowances and those payments are sent abroad.
- Covered abatement occurs within the CGE models and thus the associated abatement cost is an ex-post general equilibrium cost.
- Offset abatement is generated by external MAC curves, and thus the associated abatement cost is an ex-ante partial equilibrium cost.
- Total abatement cost is simply the sum of domestic covered abatement cost, domestic offset abatement cost, and payments for international credits.

Value of Allocated & Auctioned Allowances (IGEM)



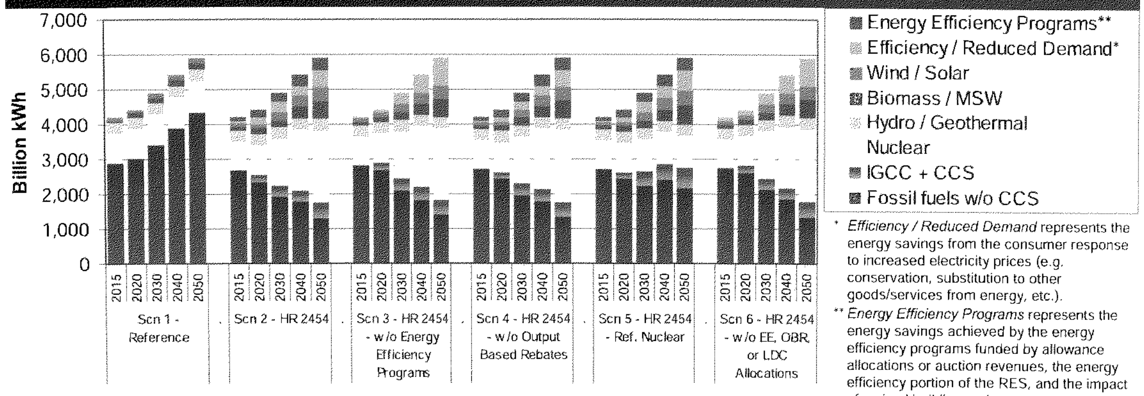
- H.R. 2454 Sec. 321 amends the Clean Air Act by inserting "Sec. 782. Allocation of Emissions Allowances." Parts (a) through (o) of this section allocate allowances for various purposes. Additionally, Sec. 781 (a) is added to allocate allowances for supplemental emissions reductions.
- The allowance price used in this figure is from the IGEM "*scenario 2 HR 2454*."
- Except where noted by an *, the uses of allowances shown here are modeled within IGEM in that the appropriate sector receives the value of the allowances, although not all of the effects of the programs specified are modeled.
- * and shown in gray, indicates that the specified allocation is not explicitly modeled in IGEM. These allowances are instead allocated lump sum to households.
- ADAGE models all of the specified uses of allowances captured in IGEM, and also models the energy efficiency provisions in subsections (b), (c) and (g).

- Both of the computable general equilibrium models used in this analysis have a single representative agent household. Any auction revenue returned to households clearly accrue to households. Additionally, any private sector revenues from allocated allowances also accrue to the employee-shareholder households. Since the model only has a single representative agent household, the differing distributional impacts of various allocation schemes are not reflected in the models.
- If auction revenues that are modeled as being returned to households lump sum were instead directed to special funds, the reduction in household annual consumption and GDP would likely be greater. If these auction revenues were instead used to lower distortionary taxes, the costs of the policy would be lower.

Energy Sector Modeling Results from Economy-Wide Modeling

U.S. Electricity Generation

H.R. 2454 Scenario Comparison (ADAGE)



* *Efficiency / Reduced Demand* represents the energy savings from the consumer response to increased electricity prices (e.g. conservation, substitution to other goods/services from energy, etc.).

** *Energy Efficiency Programs* represents the energy savings achieved by the energy efficiency programs funded by allowance allocations or auction revenues, the energy efficiency portion of the RES, and the impact of revised building codes.

- Under the policy scenarios, both nuclear and renewable electricity generation expands above the reference levels.
  - Constraints on nuclear power growth are exogenous to the model (nuclear power generation is allowed to increase by ~150% from 782 bill. kWh in 2005 to 2,081 bill. kWh in 2050). EPA plans on revising these constraints for future analyses.
- The share of renewable electricity (as defined by the RES) in the reference scenario is 6% of generation in 2015, 8% in 2020, and 10% in 2030. In "*scenario 2 – HR 2454*" the renewable generation share increases to 8% in 2015, 12% in 2020, and 20% in 2030 (other policy scenarios have similar renewable shares).
- CCS deployment on fossil-fuel generation begins in 2020 with 25 GW of CCS capacity in "*scenario 2 – HR 2454*"; by 2030, 43 GW of new CCS capacity is projected to be built; and by 2050, 60 GW of new CCS capacity is projected to be built, which is the equivalent of 109 CCS units at 550 MW each. Through 2025, ADAGE projects a greater amount of CCS generation than IPM (328 billion kWh in ADAGE vs. 198 billion kWh in IPM in 2025).
- Previous modeling of the Waxman-Markey discussion draft showed that without a subsidy for CCS, the technology would not deploy until 2040.
- In scenario 5, nuclear power is held to reference levels, resulting in a 15% increase in allowance prices, and fossil generation in 2050 equal to 2010 levels.
- See the appendix 3 for a discussion of the limitations of the methodology used for representing energy efficiency programs.

Scenario 2 & 3

H.R. 2454 Energy Efficiency Provisions Discussion

Calculated demand impacts and costs

- Impacts on electricity and natural gas demand, and associated costs, were calculated for the following energy efficiency provisions: allowance allocations to energy efficiency, building codes, and the energy savings component of the Combined Efficiency and Renewable Electricity Standard. See appendix 3 for further detail.
- In '*scenario 2 – H.R. 2454*' total electricity demand reductions are estimated to grow to 5% of reference case demand by 2020 and increase to 5.6% of AEO reference case demand in 2050.
- In '*scenario 2 – H.R. 2454*' total natural gas demand reductions are estimated to grow to 4.4% of reference case demand by 2030, and decrease to 4.3% of reference case demand in 2050.
- Cost impacts were calculated, and applied to the manufacturing and services sectors within ADAGE.

Modeled economic impacts

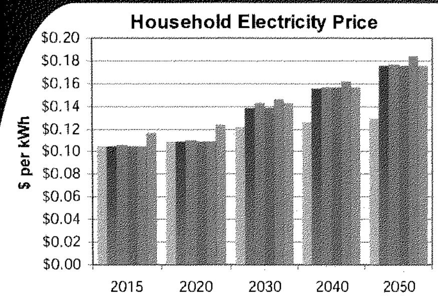
- Allowance prices are forecast to be slightly higher without energy efficiency provisions ('*scenario 3 – H.R. 2454 w/o Energy Efficiency Provisions*' relative to '*scenario 2 – H.R. 2454.*')
  - ~1.5% higher allowance prices estimated each year for 2015-2050
- Fossil fuel prices are forecast to be slightly higher for 2015-2050 without energy efficiency provisions (*scenario 3* relative to *scenario 2*).
  - Coal and Natural Gas ~1% higher
- Electricity prices are forecast to be slightly (<1%) higher for 2015-2050 without energy efficiency provisions (*scenario 3* relative to *scenario 2*).

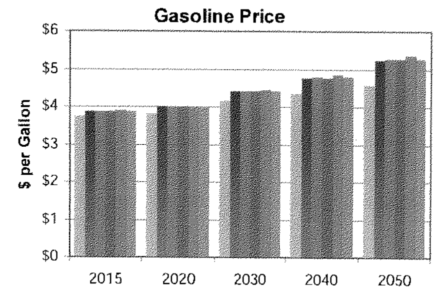
Caveats on modeling of energy efficiency provisions

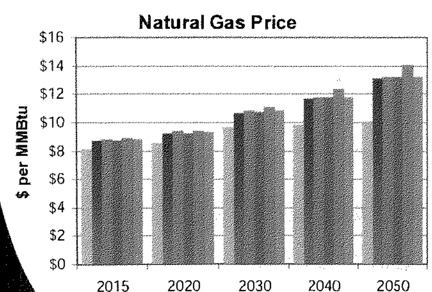
- A significant energy demand price response is forecast by ADAGE. This response is driven by a number of factors including substitution away from energy consumption to other products/services, conservation behavior (e.g., turning off lights), as well as increased investments in energy efficiency.
- A portion of estimated energy demand reduction from energy efficiency provisions may be a-priori incorporated into the baseline responsiveness of demand to a price increase in ADAGE. Further analyses are needed to quantify the extent to which demand reduction may be double-counted in this scenario.
- While the costs of the energy efficiency programs are applied to the manufacturing and services sectors of ADAGE, the cost of saved energy for energy efficiency programs is not calculated by the model.

Energy Prices

H.R. 2454 Scenario Comparison (ADAGE)





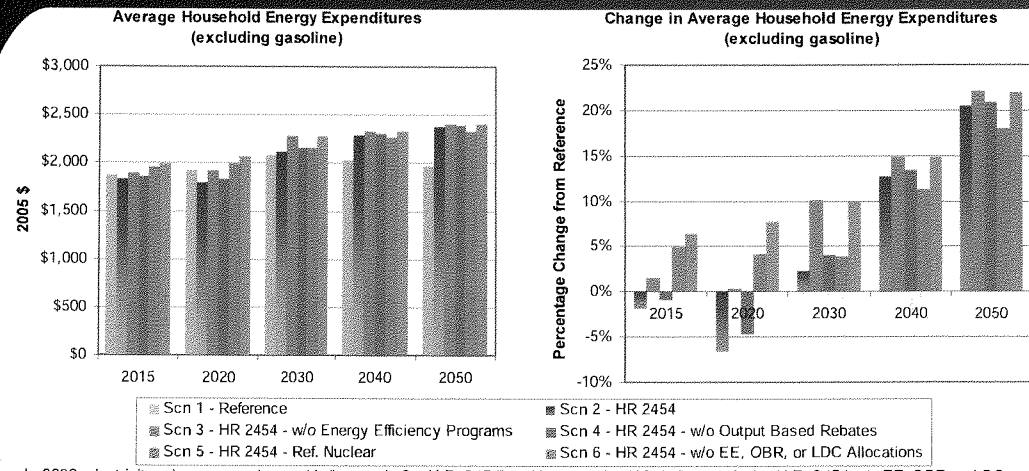


- Scn 1 - Reference
- Scn 2 - HR 2454
- Scn 3 - HR 2454 - w/o Energy Efficiency Programs
- Scn 4 - HR 2454 - w/o Output Based Rebates
- Scn 5 - HR 2454 - Ref. Nuclear
- Scn 6 - HR 2454 - w/o EE, OBR, or LDC Allocations

- Gasoline and natural gas prices are inclusive of the allowance price.
- The gasoline price is obtained by multiplying the petroleum price index in ADAGE by the 2010 price of gasoline from the AEO 2009 projection.
- See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used for representing energy efficiency programs.

Household Energy Expenditures

H.R. 2454 Scenario Comparison (ADAGE)



- In 2020, electricity prices are unchanged in "*scenario 2 – H.R. 2454*" and increase by 13% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*". In 2030, electricity prices increase by 13% in "*scenario 2 – H.R. 2454*" and increase by 17% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*".
- Actual household energy expenditures increase by a lesser amount due to reduced demand for energy. In 2020, the average household's energy expenditures (excluding motor gasoline) decrease by 7% in *scenario 2 – H.R. 2454*" and increase by 8% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*". In 2030, the increase is 2% in *scenario 2 – H.R. 2454*" and 10% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*".
- In ADAGE, energy expenditures represent approximately 2% of total consumption in 2020, falling to 1% by 2050 in all scenarios.
- The energy expenditures presented here do not include any potential increase in capital or maintenance cost associated with more energy efficient technologies.

Detailed Near-Term Electricity Sector Modeling Results

Detailed Electricity Sector Modeling with IPM

Motivation for Using the Integrated Planning Model (IPM):

- The CGE models used for this analysis do not have detailed technology representations; they are better suited for capturing long-run equilibrium responses than near-term responses.
- Since the electricity sector plays a key role in GHG mitigation, EPA has employed the Integrated Planning Model (IPM) to project the near-term impact of H.R. 2454 on the electricity sector.

Power Sector Modeling (IPM 2009 ARRA Ref. Case):

- This version of IPM builds on the versions used previously to analyze the Waxman-Markey discussion draft, S. 280, S. 1766, and S. 2191.
- This version of the model incorporates key carbon-related options and assumptions, such as carbon capture and storage technology for new and existing coal plants, biomass co-firing options, and technology penetration constraints on new nuclear, renewable, and coal with CCS capacity.
- The model has been updated to include assumptions from the revised Energy Information Administration's Annual Energy Outlook 2009, taking into account the impacts of the American Recovery and Reinvestment Act (ARRA) of 2009. This update changes the reference case forecast for renewable energy considerably.

Modeling Approach:

For this analysis, IPM 2009 ARRA Ref. Case incorporated two sets of data from the ADAGE model:

- CO_2 allowance price projections*
- Percent change in electricity demand*

Note: For more detail on the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

* Allowance prices for the core IPM scenario are taken from the ADAGE core scenario (Scenario 2).

Key Model Updates and Major Power Sector Provisions Modeled in IPM

Updates to IPM 2009 ARRA Ref. Case:

- **Electricity Demand Growth:** Calibrated to AEO 2009 ARRA update (issued in April).
- **Cost of New Power Technologies:** Consistent with AEO 2009 ARRA update.
- **Biomass:** Supply curves and non-electricity demand for biomass are calibrated to AEO 2009 ARRA update.
- **Cost of Carbon:** An increase to the capital charge rate for new coal plants (consistent with AEO 2009).
- **State RPS and Climate Programs:** Calibrated to AEO 2009 with finalized regulations like RGGI.
- **CCS in Baseline:** Reflecting updated financial incentives including ARRA, 2 GW of CCS capacity are projected for 2015 in the baseline.

Major Bill Provisions:

CCS Demonstration and Early Deployment (Title I, Subtitle B, Sec. 114): Designed to "accelerate the commercial availability of carbon dioxide capture and storage technologies and methods."

- A Carbon Storage Research Corporation is created and administers funds generated through fees on electricity production by fuel type. The Corporation, organized through EPRI, will administer and distribute roughly $1 billion in annual funding for 10 years from date of enactment.
- IPM implementation: Assumed that this funding spurs 1 additional GW of CCS capacity by 2015 (beyond the baseline amount) and an additional 4 GW by 2020. These projects are "hard-wired" into IPM and are not a result of the model's economic analysis. The model may independently add CCS capacity after 2015 on an economic basis, subject to an upper-bound capacity development constraint. The funding amounts to about $2,000/kW for 5 GW of CCS.

CCS Bonus (Title I, Subtitle B, Sec. 115): Designed to provide additional economic incentive for coal with CCS through allocation of "bonus" allowances.

- A portion of allowances are reserved for incentivizing carbon capture and storage technology (starting at 1.75% of allowances and rising to 5% through 2050). The specific incentive is designed as a fixed monetary value for every ton of CO_2 sequestered, rather than a certain number of allowances. The value is specified as up to $100/ton for the first 6 GW and is unspecified (at no greater than $90/ton) for additional support until a maximum of 72 GW of CCS receives the bonus. A stream of specified bonus allowances are made into "current" allowances and made available to qualifying projects dependent upon allowance prices and the total quantity allocated. The bonus is administered as a reverse auction.
- IPM implementation: Similar to past IPM applications, CCS projects receive a subsidy equal to the bonus amount. The allowances are distributed on a first-come, first-serve basis and can be banked. Analysis was performed for a range of potential dollar-per-ton values after the initial $90/ton for the first 6 GW. In this analysis of H.R2454, $40/ton was used as the bonus amount for generation beyond the first 6 GW.

Note: See Appendix for more detail on updates to IPM. For more detail on the all of the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html

Major Power Sector Provisions of H.R. 2454 Modeled in IPM

Major Bill Provisions (cont.):

Combined Efficiency and Renewable Electricity Standard (Title I, Subtitle A, Sec. 101): Requires retail electricity providers to meet a minimum share of sales with electricity savings and qualifying renewable generation by holding tradable credits.

- Nominal targets begin at 6% in 2012 and rise to 20% by 2020. Up to 1/4 of the target may be met with electricity savings (Governors may petition to raise this amount to 2/5). Qualifying renewable resources include solar, wind, biomass, landfill gas, and geothermal. Sales of generation from new nuclear, new CCS†, and existing hydropower capacity are deducted from a retail provider's total sales for assessing the CERES requirement. The bill allows sources to bank federal Renewable Electricity Credits (RECs) for 3 years following generation. Retailers selling less than 4 million MWh a year are exempted from CERES.
- IPM implementation: Reductions in electricity consumption are assumed to meet 1/4 of the standard's targets, which are reduced accordingly.* Estimated sales from hydro generation, new CCS† generation, and new nuclear generation (as projected by IPM in the main H.R. 2454 policy case) are deducted from total sales to establish the qualifying sales levels for meeting CERES. Banking is not explicitly modeled but is implicitly included because the model runs roughly every 5 years. The share of sales from exempted retailers is assumed to remain constant at about 23% (its 2007 level) and is removed from CERES assessment.

Allowance Allocation to Local Distribution Companies (Title III, Subtitle B, Sec. 783): Distributes allowances to electricity local distribution companies (LDCs) "for the benefit of retail ratepayers."

- LDCs collectively receive a declining share of allowances to 2030, beginning at about 39% in 2012 and ending with about 6% in 2029.‡ Half of those allowances are disbursed to LDCs based on historic GHG emissions. The remaining allowances are disbursed based on an updating measure of an LDC's population served (revised every 3 years). LDCs are required to direct allowance value toward "ratepayer benefit," which may range from energy efficiency improvements to consumer rebates. For the latter purpose, the bill encourages LDCs and their regulators to issue lump sum rebates.
- IPM implementation: Allowance prices and electricity demand response are taken from the core ADAGE H.R. 2454 Scenario (#2), which reflects the LDCs allocation as rebates based on electricity consumption.

* Assumptions for energy efficiency are detailed earlier in this presentation and are taken from the ADAGE model.

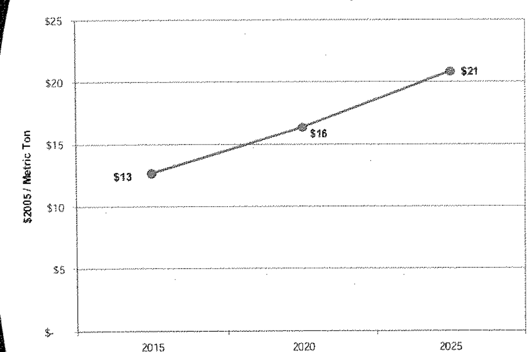
† Sales of generation from CCS is only deducted from the CERES baseline equivalent to the percentage of carbon capture achieved, which is assumed to be 90% in this analysis.

‡ The bill directs EPA to reserve up to 10% of the electricity consumer allocation for distribution to generators subject to long-term contracts and to merchant coal generators. The remaining amount is estimated here for LDCs.

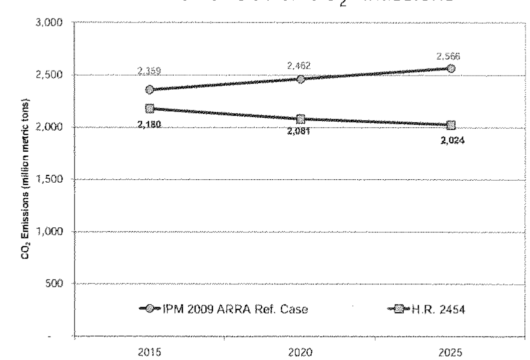
Note: See Appendix for more detail on updates to IPM. For more detail on the all of the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html

GHG Allowance Prices and Power Sector CO_2 Emissions (IPM)*

GHG Allowance Price (inputs to IPM)*

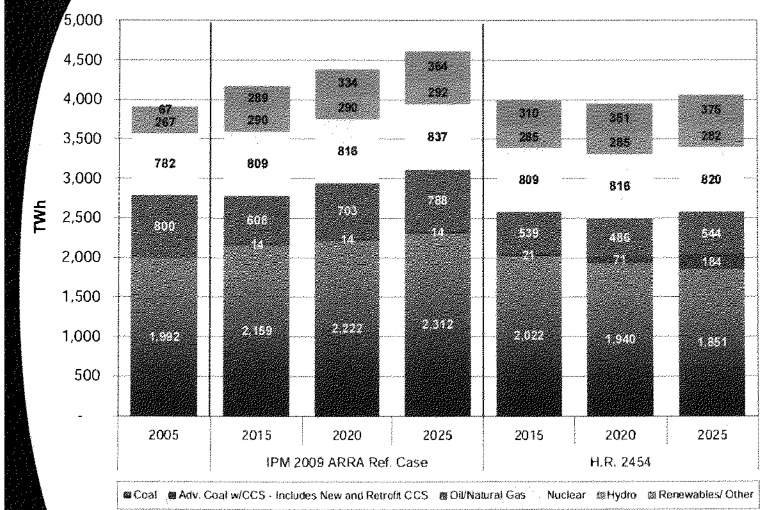


Power Sector CO_2 Emissions



* Allowance prices for the core IPM scenario are taken from the ADAGE core scenario (Scenario 2). IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables.

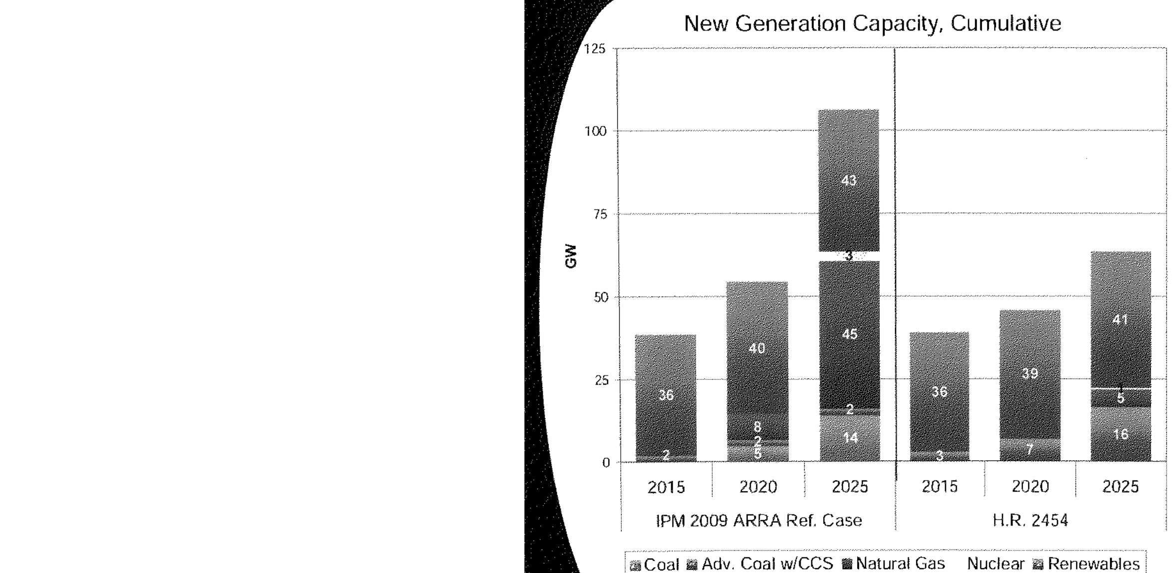
Electricity Generation Mix (IPM)



- The electricity demand forecast is lower than past EPA analyses, reflecting economic and policy-related adjustments.
- Due to a large increase in renewable energy largely driven by ARRA provisions, there is excess electricity generating capacity projected through 2015 in the reference case and H.R. 2454 scenario.
  - This tends to drive generation away from existing natural gas.
- The difference in electricity generation between the reference case and policy case due to energy efficiency and demand response is around 550 TWh in 2025. This difference is equivalent to the amount of electricity used by over 40 million (50% of the total) single family homes in the US annually.*
- There is greater renewable generation in the H.R.2454 scenario even though less new renewable generation is built because of greater reliance on bio-mass co-firing at existing coal plants.

2005 data from EIA's Electric Power Annual (for electric utilities, independent power producers, and CHP electric power). IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables.
*EIA. 2005 Residential Energy Consumption Survey. Table 3. http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html.

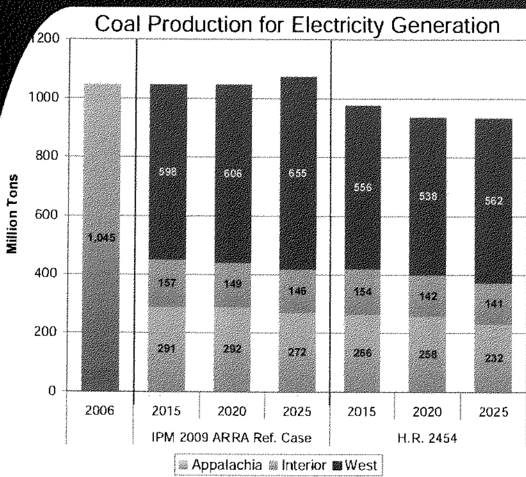
New Generation Capacity (IPM)

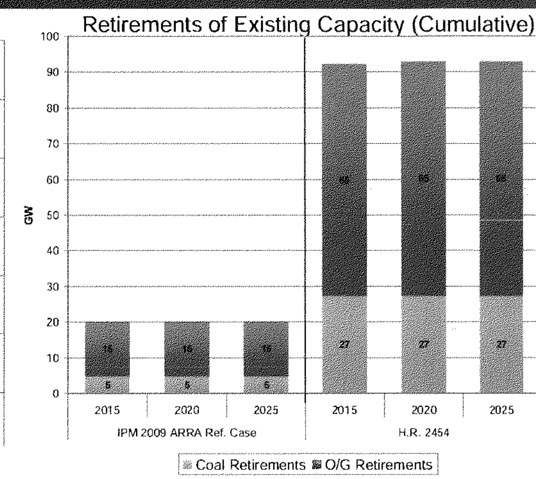


- A major change to the IPM 2009 ARRA reference case is the amount of new renewables expected to be built in the short-term in response to additional ARRA incentives. Overall electricity demand is also lower, necessitating fewer new power plants than past EPA modeling with IPM.
- Under H.R. 2454, electricity demand is reduced significantly and allowance prices are not high enough to drive a significant amount of additional low- or zero- carbon energy (including nuclear, renewables, and CCS) in the shorter-term, excluding the technologies with specific financial incentives (e.g., CCS).
- H.R. 2454 contains early deployment funding and a bonus allowance provision for CO_2 emissions that are captured and sequestered, resulting in some penetration of *new* coal capacity with CCS technology.
  - The policy results in a total of 14 GW of additional new capacity with CCS by 2025. Of that amount, 5 GW is forced in IPM beyond the reference case by 2020 to reflect early deployment funding. The other 9 GW becomes economic due to the bonus allowance allocation (see later slide).
  - CCS retrofits to the *existing* coal fleet are also economic, facilitated by the bonus (retrofits to existing facilities are not reflected in the graphic).
    - There are about 9 GW in 2025 of post-retrofit capacity, which meets IPM's CCS retrofit penetration limit (while the limit on new CCS capacity penetration is not reached).*
- The amount of new nuclear capacity is well below the penetration limit throughout the entire modeling period.

Note: New capacity additions less that 1 GW of capacity are not indicated. IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables. IPM projects less new nuclear and slightly less new renewable capacity compared to AEO 2009 ARRA. * See appendix for more detail on EPA's technology penetration limits applied in IPM.

Coal Production for Electricity Generation & Retirements of Existing Capacity (IPM)

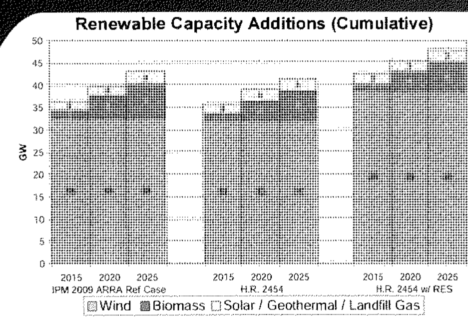


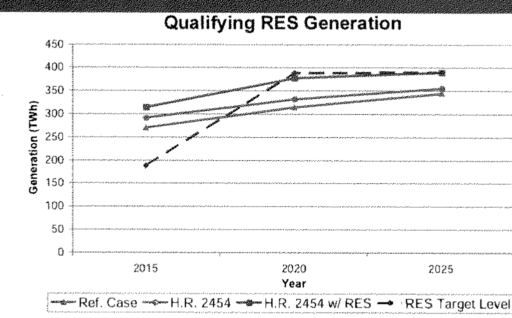


- Roughly 22 GW of additional existing coal capacity and 70 GW of additional oil/gas capacity is projected to retire under H.R. 2454. The lower allowance prices and higher costs to build new technology make existing coal cost-competitive in the shorter-term.
- In reality, uneconomic units may be "mothballed," retired, or kept running to ensure generation reliability. The model is unable to distinguish among these potential outcomes. Most of these are marginal units with low capacity factors.
- Most uneconomic units are part of larger plants that are expected to continue generating. Currently, there is roughly 120 GW of oil/gas steam capacity and 320 GW of coal capacity.

Note: Regional coal production data includes coal production for power generation only. Historical data is from EIA's AEO 2008. Coal production (in terms of tons) does not correlate to generation perfectly because different grades of coal have greater heat content (e.g. bituminous coal has greater heat content than sub-bituminous coal). In addition, coal production data shown here does not include coal imports, which increase over time in IPM. IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables.

Effects of the Combined Efficiency and Renewable Electricity Standard (CERES)





- The core case for H.R. 2454 illustrates how the bill's provisions for increased energy efficiency reduce the need for new capacity additions (including renewables), even as renewable generation rises. The RES portion of CERES is shown here to increase deployment of renewable capacity, and it results in a more substantial increase in renewable generation than the cap-and-trade system yields on its own.
  - The RES also reduces average natural gas prices, gas consumption, and wholesale electricity prices by about 1-2% throughout the model's time horizon. Initial analysis indicates that retail electricity prices rise slightly relative to the core H.R. 2454 scenario in later years. The impact on a household's electricity bill, however, would be offset to the extent that efficiency gains would reduce overall power consumption.
  - The share of renewable electricity (as defined by the RES) in the IPM reference scenario is roughly 7% of generation in 2020 and 2025. In Scenario 2 (H.R. 2454), the renewable generation share increases to 8% in 2020 and 9% in 2025. And in Scenario 2 with the RES, renewable generation is 9% in 2020 and 10% in 2025.
- The power sector is projected to reach the bill's RES targets through 2015 in the reference case (with 25% from electricity savings assumed).
- H.R. 2454 includes an alternative compliance payment (ACP) of $25 per MWh. This analysis projects that the federal Renewable Electricity Credit (REC) price reaches that level in 2020 but falls back to about $11 per MWh in 2025.
  - Use of the ACP in 2020 is very limited (accounting for only 2% of total CERES compliance).
  - H.R. 2454 also allows States to petition for the right to meet up to 40% of the CERES with electricity savings. Additional use of efficiency to meet the standards would lower federal Renewable Electricity Credit (REC) prices, potentially reducing use of the ACP.
  - This analysis does not take into account the effect of ACP payments, which H.R. 2454 reserves for States to increase the deployment of renewables or increase electricity savings.
- By increasing the share of renewable generation, the RES would likely lower power sector GHG emissions and could lower the economy-wide allowance price, although this effect was not modeled in the analysis. To the degree that the RES requires generation or capacity deployment that is not most cost effective otherwise, total system costs increase. RES would not impact the achievement of the emission caps under H.R. 2454.

Note: IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables. For more detail on natural gas impacts of the RES, see slide 93 of the Appendix.

Effects of Allocating Allowances to Electricity Local Distribution Companies

- Under lump sum rebate allocation, consumers pay higher electricity rates but receive payments irrespective of their consumption; therefore, the payments do not dampen the price incentive for more efficient use of electricity.

- Where allowance value is rebated to consumers on the basis of quantity consumed, electricity prices will be lower and thus consumption will be higher than would have occurred otherwise. Higher consumption yields higher GHG emissions from the power sector, which means other reductions will be needed that could lead to higher economy-wide allowance prices. EPA is doing additional analysis to examine the extent to which LDC allocation value impacts power prices, emissions, allowance prices, and developments in power sector generation and capacity.

- Note that any evaluation of the impact on consumers must examine electricity prices and total electric power consumption (e.g., monthly bills) together with other costs (e.g., efficiency investments) to get the full picture.

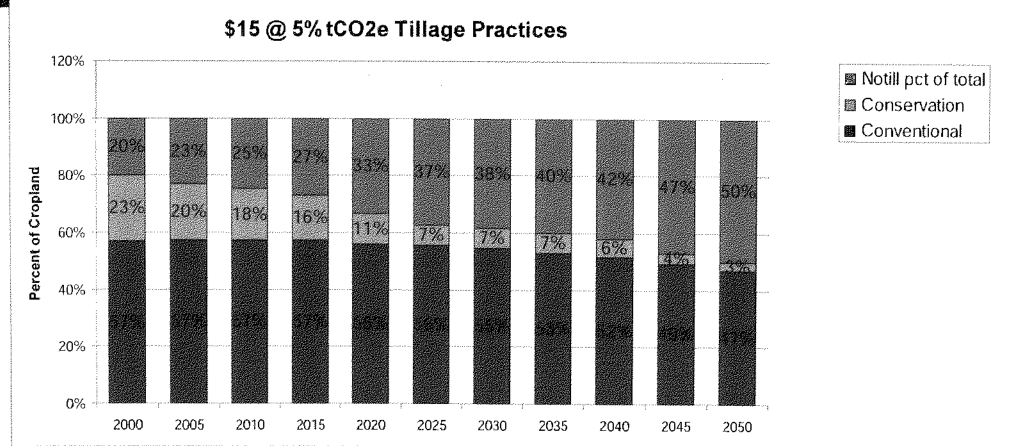
Offsets Usage & Limits

Factors Influencing Domestic Offset Supply

- The analysis of domestic forest and agriculture offsets is based on the FASOM marginal abatement cost curves used in the April 20th analysis of the Waxman-Markey Discussion Draft.
- The modeling of domestic offsets evaluates changes in greenhouse gases against a projected baseline. If offsets are evaluated against historic or current baselines, the overall volume of offsets would increase.
- The sources of domestic offsets modeled here represent sources that have significant supply in the FASOM model at the relevant allowance prices. The exclusion of other sources in the modeling results does not imply that those sources would not be eligible to receive offsets credits.
- The FASOM modeling did not account for several categories of potential agricultural GHG reductions, including:
    - Improvements in organic soil management;
    - Advances in feed management of ruminants;
    - Changes in the timing, form, and method of fertilizer application; and
    - Alternative manure management systems – other than anaerobic digesters
- Because of how it is handled in the model, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50% increase in the percent of cropland using conservation-tillage and no-till by 2020 in response to a $15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.
- Within the model, reductions in fertilizer use result in declines in yields. To the extent fertilizer application can be improved without yield penalties, the potential for this category of emissions reductions will be higher.
- EPA is working with USDA to review the analysis of the forestry and agricultural sectors.

Increased Use of No-Till Under Increasing Carbon Prices

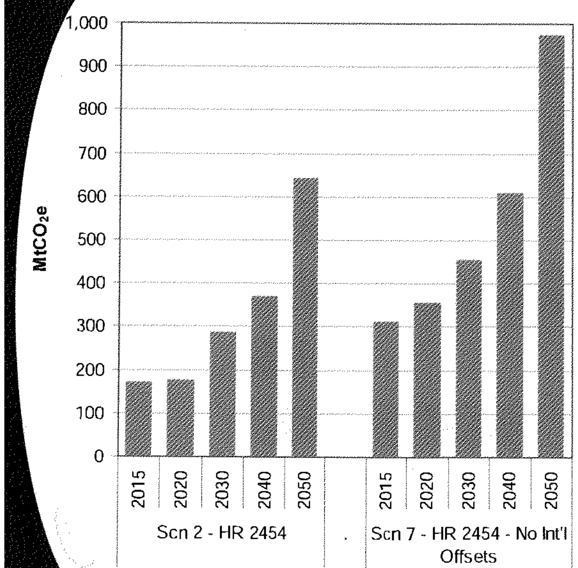
FASOM



- The above graphic represents the share of cropland under different tillage practices in one of the FASOM runs that contribute to the marginal abatement cost curves used for representing domestic offsets abatement potential. The specific run is based on an initial allowance price of \$15/tCO_2e rising at five percent.
- Because of how it is handled in the model, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50% increase in the percent of cropland using conservation-tillage and no-till by 2020 in response to a \$15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.

Domestic Offsets Usage

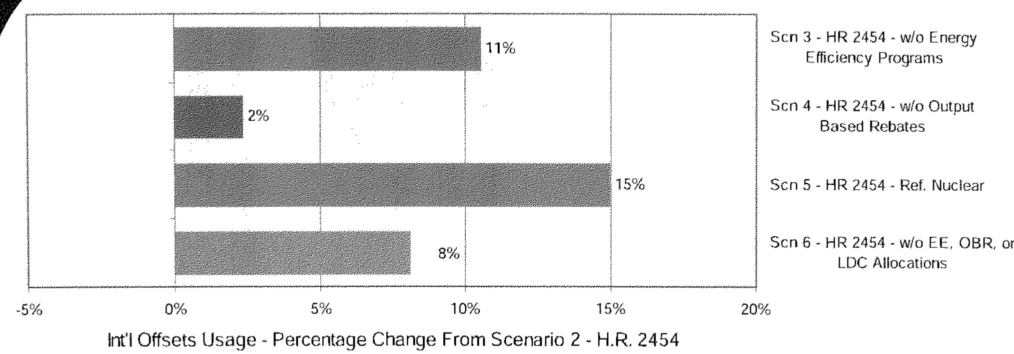
H.R. 2454 Scenario Comparison (IGEM)



- The annual limit on the usage of domestic offsets is non-binding.
  - H.R. 2454 Sec 722 (d) (1) (A) allows covered entities to collectively use offset credits to demonstrate compliance for up to a maximum of 2 billion tons of GHG emissions annually.
  - This section also attempts to share the 2 billion tons of offsets allowed pro rata among covered entities. However, the formula specified for pro rata sharing among covered entities does not result in 2 billion tons of offsets in total.
  - H.R. 2454 Sec 722 (d) (1) (C) modifies the pro rata sharing to allow more international offsets if fewer than 0.9 GtCO2e are expected to be used.
  - See appendix 2 for a detailed discussion of the offsets provisions in H.R. 2454.
- In our analysis, we assume that landfill and coal mine CH_4 are covered under new source performance standards (NSPS) and are thus not available for offsets.
  - EPA's previous analysis of the Waxman-Markey discussion draft showed that allowing landfill and coal mine methane as offset projects instead of covering them under NSPS would increase cumulative domestic offsets usage by 45%.
- Restricting the use of international offsets, as in "*scenario 7 – H.R. 2454 No Int'l Offsets*" has a large impact on allowance prices (89% increase relative to '*scenario 2 – H.R. 2454*').

International Offsets Usage Sensitivities

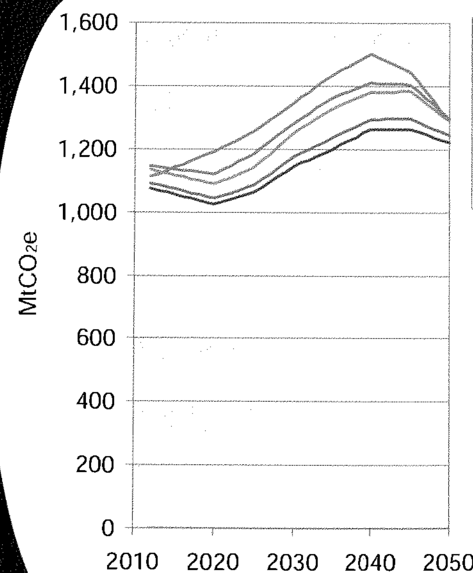
H.R. 2454 Scenario Comparison (ADAGE)



- Since the annual limit on the usage of international offsets is non-binding in most scenarios, sensitivities that would be expected to impact allowance prices, instead impact the usage of international offsets (and thus the amount of abatement within covered sectors).
- For example, in EPA's analysis of the Waxman-Markey discussion draft (WM-draft), the sensitivity case adding in the energy efficiency programs resulted in a 9% decrease in allowance prices. In this analysis of H.R. 2454, the sensitivity case removing the energy efficiency programs only increases allowance prices by 2%. The difference is that in the WM-draft analysis the cumulative U.S. covered emissions were the same in the two scenarios; whereas, in the H.R. 2454 analysis, removing the energy efficiency programs increases the marginal cost of abatement, but instead of allowance prices increasing to achieve the same level of abatement, the usage of international offsets increases and the amount of abatement decreases so cumulative U.S. covered emissions increase.

International Offsets Usage

H.R. 2454 Scenario Comparison (ADAGE)



Cumulative International Offsets Usage (GtCO2e)	
Scn 2 - HR 2454	45
Scn 3 - HR 2454 - w/o Energy Efficiency Programs	50
Scn 4 - HR 2454 - w/o Output-Based Rebates	46
Scn 5 - HR 2454 - Reference Nuclear	52
Scn 6 - HR 2454 - w/ Lump Sum LDC Rebates	48

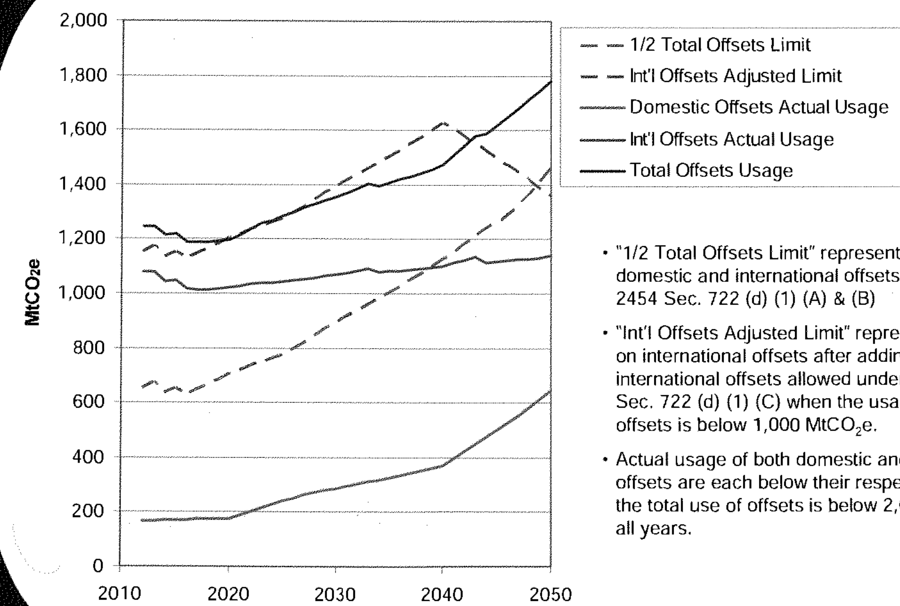
H.R. 2454 Offsets Provisions

Sec. 722 (d) (1)

- H.R. 2454 Sec 722 (d) (1) (A) allows covered entities to collectively use offset credits to demonstrate compliance for up to a maximum of 2 billion tons of GHG emissions annually.
- This section also attempts to share the 2 billion tons of offsets allowed pro rata among covered entities. However, the formula specified for pro rata sharing among covered entities does not result in 2 billion tons of offsets in total.
  - Covered entities are allowed to satisfy a specified percentage of the number of allowances required to be held for compliance with offsets credits.
  - H.R. 2454 Sec 722 (d) (1) (B) shows that for each year, the specified percentage is calculated by dividing two billion by the sum of two billion and the annual tonnage limit for that year. For example, in 2012, when the cap level is 4.627 GtCO2e, the percentage would be 30.20%; and in 2050, when the cap level is 1.035 GtCO2e the percentage would be 65.90%.
  - The number of allowances required to be held for compliance is equal to the amount of covered emissions, so for any given firm the amount of offsets they are allowed to use is equal to the product of their covered emissions and the percentage specified above.
  - The total amount of offsets allowed is equal to the product of the total amount of covered emissions and the specified percentage. In order for this to be equal to the 2 billion ton limit on offsets specified above, total covered GHG emissions would have to be equal to the cap level plus 2 billion tons. There are several reasons why this is unlikely to be the case.
    - First, even if covered emissions remain at reference levels, in the early years of the policy they will not be 2 billion tons over the cap level.
    - Second, if firms bank allowances, their covered GHG emissions will be reduced, which will reduce the amount of offsets they are allowed to use.
    - Third, in the later years when firms are drawing down their bank of allowances, it is possible for covered GHG emissions to be more than 2 billion tons above the cap, which means that the pro rata sharing formula can be in conflict with the overall 2 GtCO2e limit on offsets usage. However, if the domestic limit is non-binding, then the pro-rata sharing would allow for the international limit to exceed 1 GtCO2e, so long as the sum of domestic and international offsets were still below 2 GtCO2e.
- H.R. 2454 Sec 722 (d) (1) (C) modifies the pro rata sharing to allow more international offsets if fewer than 0.9 GtCO2e are expected to be used.
  - In years when this provision triggers, an additional amount of international offsets are allowed equal to the lesser of: 1 GtCO2e less the actual amount of domestic offsets used; or 0.5 GtCO2e.
  - This has the potential in later years to allow more than 2 GtCO2e of offsets into the system, so our interpretation is that the actual amount of extra international offsets allowed would be equal to the lesser of the amount calculated above, or 2 GtCO2e less the sum of the international offsets limit and the actual usage of domestic offsets.
  - Because the pro-rata sharing limits domestic offsets in the early years to well below 0.9 GtCO2e, this provision will automatically trigger, even if the actual limit on domestic offsets were binding.

Domestic & International Offsets Usage & Limits

Scenario 2 – H.R. 2454 (IGEM)



- "1/2 Total Offsets Limit" represents the limits on domestic and international offsets based on H.R. 2454 Sec. 722 (d) (1) (A) & (B)
- "Int'l Offsets Adjusted Limit" represents the limit on international offsets after adding in the extra international offsets allowed under H.R. 2454 Sec. 722 (d) (1) (C) when the usage of domestic offsets is below 1,000 $MtCO_2e$.
- Actual usage of both domestic and international offsets are each below their respective limits, and the total use of offsets is below 2,000 $MtCO_2e$ in all years.

International Offsets Sensitivities

Side Scenarios (IGEM)

Because of the importance of international offsets, several side scenarios are included here to further explore the relationship between the availability of international offsets and the price of domestic allowances. A reduced form version of the IGEM model was used for these side scenarios.

Scenario 2 – H.R. 2454
- One of the main scenarios.

Scenario 7 – H.R. 2454 with No International Offsets
- One of the main scenarios.

Scenario 7a – H.R. 2454 with Delayed International Offsets
- Side scenario.
- No international offsets are allowed in the first 10 years.

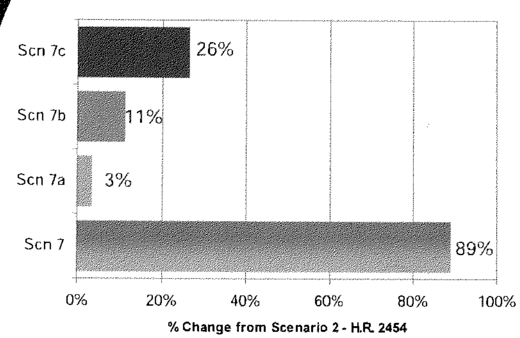
Scenario 7b – H.R. 2454 with No Extra International Offsets
- Side scenario
- No extra international offsets from H.R. 2454 Sec 722 (d) (1) (C) when domestic offset usage is below 900 $MtCO_2e$.

Scenario 7c – H.R. 2454 with Delayed International Offsets & No Extra International Offsets
- Side scenario
- No international offsets are allowed in the first 10 years.
- No extra international offsets from H.R. 2454 Sec 722 (d) (1) (C) when domestic offset usage is below 900 $MtCO_2e$.

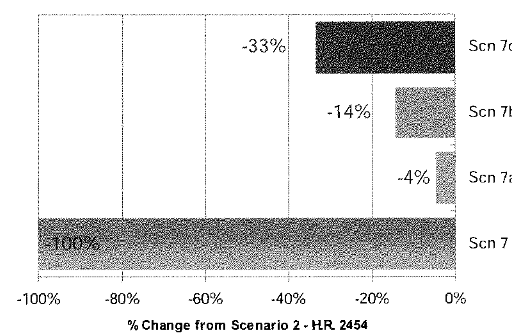
International Offsets Sensitivities

Allowance Prices & Cumulative International Offsets (IGEM)

Marginal Cost of GHG Abatement Sensitivities



Cumulative Int'l Offsets Usage (2012-2050)



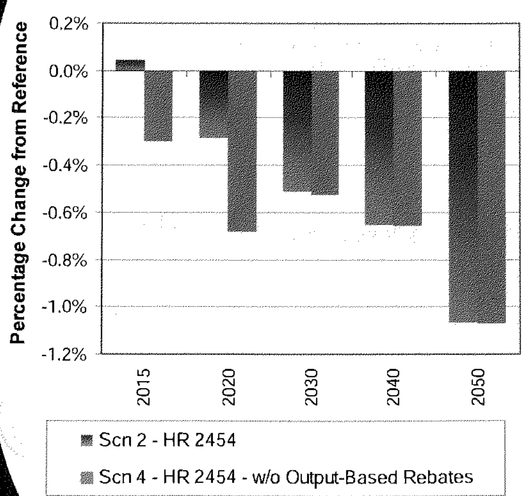
Cumulative International Offsets Usage (GtCO2e)	
Scn 2 - H.R. 2454	42
Scn 7 - H.R. 2454 - No Int'l Offsets	0
Scn 7a - H.R. 2454 - Delayed Int'l Offsets	40
Scn 7b - H.R. 2454 - No Extra Int'l Offsets	36
Scn 7c - H.R. 2454 - Delayed & No Extra Int'l Offsets	28

Global Results:
Trade Impacts and
Output-Based Rebate Provisions

Summary of Trade Impacts and Output-Based Rebate Provisions

(ADAGE)

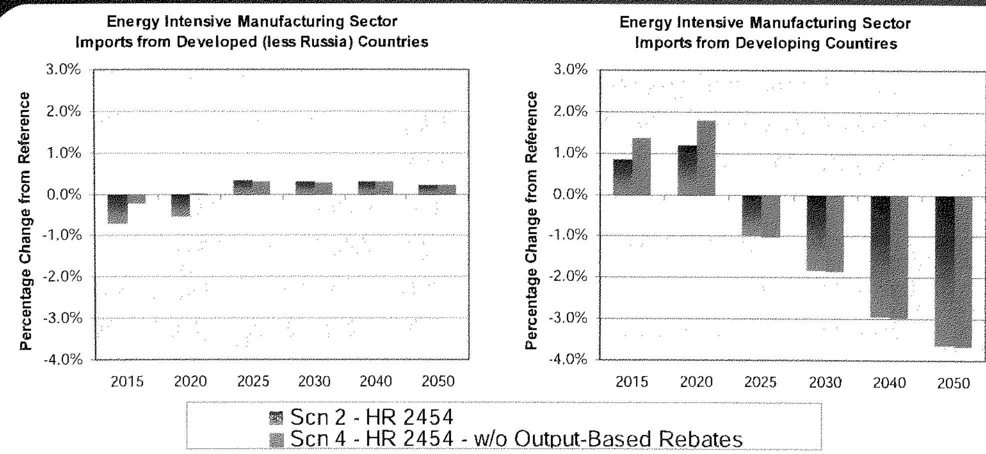
U.S. Energy Intensive Manufacturing Sector Output



- The output-based rebate provision specified in Title IV of H.R 2454 is similar to H.R. 7146 (Inslee - Doyle).
  - Applies to energy- or GHG-intensive industries that are also trade-intensive.
  - Rebates on average 100 percent of the direct and indirect cost of allowances, based on an individual firm's output and the average GHG and energy intensity for the industry.
  - Gradually phases out between 2025 and 2035, or when other countries take comparable action on climate change.
- Without output-based rebate provision, energy intensive manufacturing output decreases by 0.3% in 2015 and by 0.7% in 2020. With the output-based rebates, energy intensive manufacturing output *increases* by 0.04% in 2015 and only falls by 0.3% in 2020.
- The output-based rebate provisions have little impact on allowance prices, and thus, in later years after the rebates are phased out, the energy intensive manufacturing sector output losses are similar in the two scenarios.
- More detailed results are presented in Appendix 5.

Summary of Trade Impacts and Output-Based Rebate Provisions

(ADAGE)

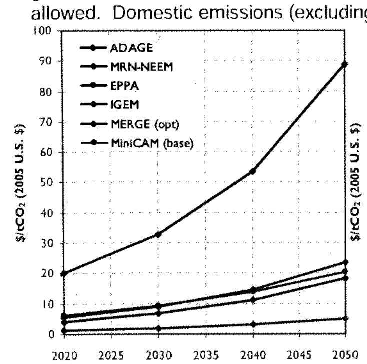


- Imports of energy intensive manufacturing goods from developing countries increase in 2015 and 2020, then decrease in 2025 and after as the developing countries are assumed to adopt climate policies.
- In 2015 and 2020, the output-based rebate provisions decrease imports from both developed and developing countries.
- More detailed results are presented in Appendix 5.

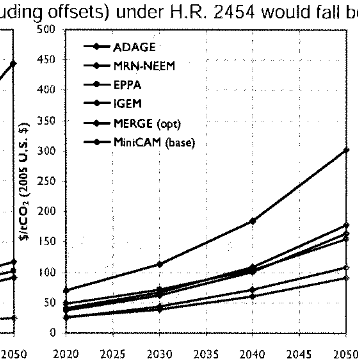
Literature Review

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

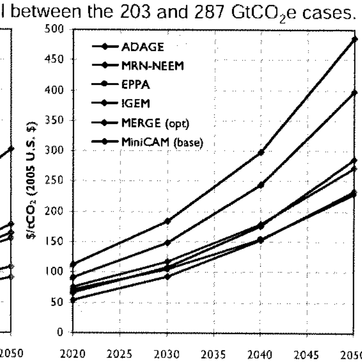
To put the EPA models (ADAGE and IGEM) in context, we compare the results of EMF's analysis of three emission goals that span a wide range of possible U.S. 2050 targets. Caps are based on CO_2-equivalents (CO_2-e), covering all Kyoto gases. These scenarios were not intended to represent any specific bill, and no domestic or international offsets are allowed. Domestic emissions (excluding offsets) under H.R. 2454 would fall between the 203 and 287 $GtCO_2e$ cases.



287 $GtCO_2$-e



203 $GtCO_2$-e



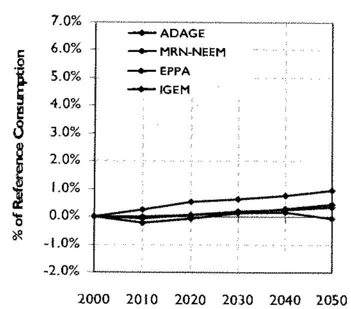
167 $GtCO_2$-e

- 287 bmt CO_2-e: ADAGE, IGEM and EPPA predict a similar rise in allowance prices. The cost of allowances rises from approximately $4-$6 per ton in 2020 to $20-$25 in 2050, however MiniCAM predicts only a small increase in allowance prices ($1 to $5), while NEEM predicts allowance prices will rise from $20 in 2020 to nearly $90 in 2050.
- 203 bmt CO_2-e: All models predict similar allowances prices in 2020 ($25-$70 per ton), but predict different growth rates resulting in a relatively wide range of allowance prices ($90 to $180; NEEM over $300) in 2050 .
- 167 bmt CO_2-e: All models predict relatively similar allowances prices in 2020 ($55-$115 per ton), but predict different growth rates resulting in a relatively wide range of allowance prices ($230 to $485) in 2050

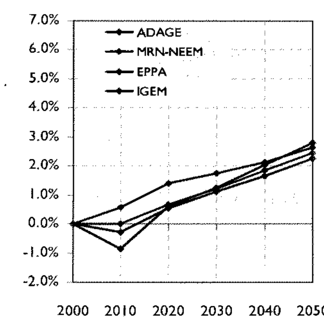
Comparing Costs of Three Possible U.S. Emissions Targets through 2050

Changes in consumption approximate changes in consumer welfare

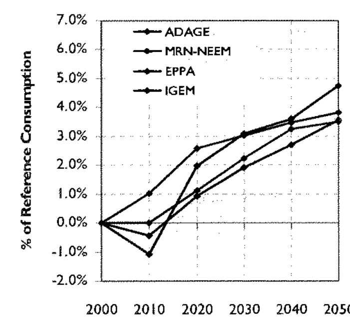
Annual Consumption Losses across Scenarios



287 bmt CO_2-e



203 bmt CO_2-e



167 bmt CO_2-e

- 287 bmt CO_2-e: Annual consumption losses remain below 1% for all models through 2050.
- 203 bmt CO_2-e: Annual consumption losses are all 1.4% or below in 2020 and rise to between 2.25% to 2.8% in 2050.
- 167 bmt CO_2-e: Annual consumption losses are between 1% and 2.6% in 2020 and rise to between 3.5% to 4.75% in 2050.

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

• Different Models, Different Baselines and Assumptions

	EPA	MIT	CRA	EPRI	PNNL
Model	ADAGE,IGEM	EPPA	MRN-NEEM	MERGE	MiniCAM
Baseline	AEO 2008 Early Release*	AEO 2009 Early Release	AEO 2008 Early Release	Own baseline	Own baseline
Nuclear Assumptions	Capacity grows at 150% 2005 levels	Not permitted to expand in the base case (Advanced Nuclear available in 2020)	Capacity limited but growing over time (3 GW in 2015; 100 GW in 2050)	New capacity in 2020: capacity limited but growing over time subject to uranium supply constraints	Soft constraints in 2020; after 2020 allowed to grow unconstrained (Advanced nuclear case)
CCS Assumptions	Available in 2020	Available in 2020	Available in 2015 but with capacity limits	Available in 2020; allowed to triple each decade	Available in 2020

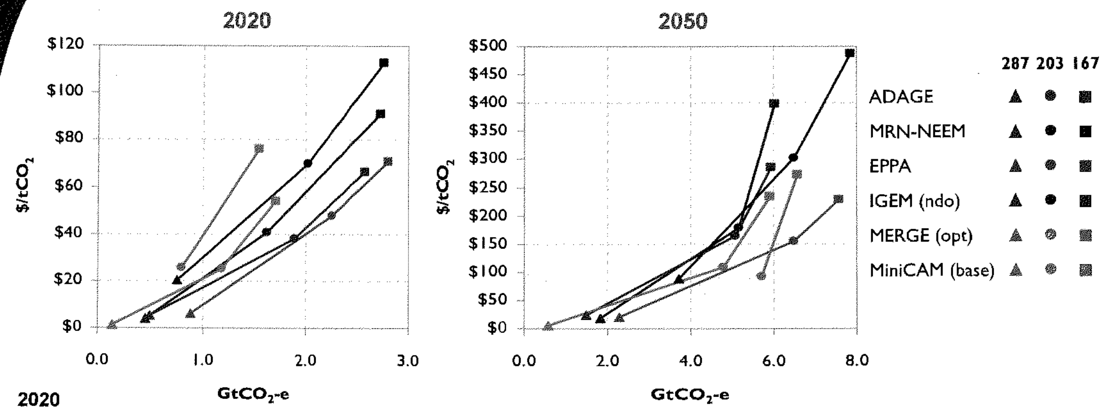
*** AEO 2008 Early release was used by the EPA models for EMF-22. The baseline in EPA's H.R. 2454 analysis is AEO 2009 (March release).**

Common messages from the models

- The majority of the cost-effective reductions come from the electricity sector.
- Greater expansion in nuclear power reduces the costs
- CCS is an important enabling technology

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

Marginal Abatement Cost Functions (MACs) in 2020 and 2050



2020

- All models, except MERGE, require abatement of less than 1 $GtCO_2$-e to reach 287 bmt – MACs range from $1-$6, except for NEEM, which reaches $20
- All models require abatement between 0.8-2.25 GtCO2-e to reach the 203 bmt – MACs range from $25-$70
- All models, except MERGE and MiniCAM, require abatement between 1.55-2.8 GtCO2-e to reach 167 bmt – MACs range from $55-$113

2050

- All models, except MERGE, require abatement between 0.6-3.75 GtCO2-e to reach 287 bmt – MACs range from $5-$25, except NEEM which reaches $90
- All models require abatement between 4.8-6.5 GtCO2-e to reach 203 bmt – MACs range from $90-$180, except NEEM, which reaches $300
- All models require 6-8 GtCO2-e to reach 167 bmt – MACs range from $230-$485.

Household Distributional Issues

- There is relatively little analysis in the economics literature on how benefits from a domestic GHG or carbon cap-and-trade policy are distributed across U.S. households. There are more analyses of the distribution of the costs associated with a cap-and-trade policy.
  - These studies' findings are briefly summarized here (Fullerton, forthcoming; Parry 2004; Dinan and Lim Rogers 2002; Rose and Oladosu 2002).
- A cap-and-trade policy increases the price of energy-intensive goods. The majority of this price increase is ultimately passed onto consumers.
- Before accounting for the way in which allowances are allocated or revenues are redistributed, lower income households are disproportionally affected by a GHG cap-and-trade policy because they spend a higher fraction of their incomes on energy-intensive goods.
- The way in which allowances are allocated (auctioned or given away) and how any revenues collected are utilized affects the distribution of costs across households.
- Freely distributed allowances to firms tends to be very regressive.
  - Higher income households may actually gain at the expense of lower income households under this policy. This is because the asset value of the allowances flow to households in the form of increased stock values or capital gains, which are concentrated in higher-income households.
  - The government would collect some additional revenue via a tax on profits; the stringency of the profit tax and the use of this revenue may have distributional effects. For instance, lump sum distribution of revenues makes the policy look less regressive than lowering of payroll or corporate taxes.
- If allowances are auctioned, revenues can be used to influence the regressivity of the policy.
  - Revenues can be redistributed in the form of lower payroll or corporate taxes. These options tend to look less regressive when paired with auctioned allowances then when combined with free allocation but more regressive than equal lump-sum rebates to households.
  - Auctioned allowances with lump-sum distribution of revenues to households is the least regressive cap-and-trade policy analyzed and has been shown to be progressive in some cases.
- Returning the allowance value to consumers of electricity via local distribution companies in a non-lump sum fashion prevents electricity prices from rising but makes the cap-and-trade policy more costly overall.
  - This form of redistribution makes the cap-and-trade more costly since greater emission reductions have to be achieved by other sectors of the economy.
  - Resulting changes in prices of other energy-intensive goods also influence the overall distributional impacts of the policy.

Household Distributional Issues

- As way of illustration, Metcalf (2007) examines the distributional implications of a \$15/ton CO_2 tax.
  - This is equivalent to a cap-and-trade policy with full auctioning.
  - This price is roughly equivalent to what is predicted to occur in this EPA analysis under Waxman-Markey in 2015.
- Metcalf's main case redistributes the revenue via an earned income tax credit
  - The tax credit is equal to total (employer and employee) payroll taxes paid in the current year, up to a maximum of \$560.
  - This is equivalent to exempting the first \$3,660 of wages per covered worker.
- Before the tax credit, the policy is regressive. After accounting for the tax credit, the policy is progressive.
- Metcalf also illustrates how the distributional impacts may change if the revenue is redistributed in others ways.
  - Including social security lowers the maximum tax credit available to \$420 and makes the policy more progressive. A per capita lump sum rebate of \$274 further increases progressivity relative to an earned income tax credit.

Income group	\$15/ton Tax		Earned Income		Earned Income and Social Security		Lump Sum	
(decile)	Net (\$)	Net (%)	Net (\$)	Net (%)	Net (\$)	Net (%)	Net (\$)	Net (%)
1 (lowest)	-\$276	-3.4	-\$68	-0.7	\$112	1.4	\$166	2.1
2	-\$404	-3.1	-\$120	-1	\$125	1.0	\$128	1.0
3	-\$485	-2.4	-\$57	-0.2	\$114	0.6	\$120	0.6
4	-\$551	-2	\$6	0.1	\$70	0.3	\$103	0.4
5	-\$642	-1.8	\$26	0.1	\$54	0.1	\$108	0.3
6	-\$691	-1.5	\$115	0.3	\$66	0.1	\$26	0.1
7	-\$781	-1.4	\$135	0.2	\$35	0.1	-\$32	-0.1
8	-\$883	-1.2	\$99	0.2	-\$61	-0.1	-\$52	-0.1
9	-\$965	-1.1	\$70	0	-\$95	-0.1	-\$171	-0.2
10 (highest)	-\$1,224	-0.8	-\$130	0	-\$332	-0.2	-\$355	-0.2

* Metcalf uses 2003 Consumer Expenditure Survey data and assumes payroll tax rules from 2005.

Household Distributional Issues

- Recent, but still unpublished, studies have explored regional differences in the distributional effects of many allowance allocation and revenue distribution options for a carbon cap-and-trade policy (Burtraw et al. 2009, Hassett et al. 2007).
  - Regional differences result from differences in pre-existing policies, consumption levels, pricing of electricity, and the inputs used to produce energy goods (e.g. coal, natural gas).
  - For instance, a cap-and- (taxable) dividend policy that results in a $20.87/metric ton CO_2 price is estimated to result in an average welfare gain of 3.6% for the 20% poorest households. However, regionally, this varies from 1.9% to 5.4%.
- Most of these studies use annual household expenditures as a proxy for income. When a wealth measure is used instead, the distributional difference between low and high income households is less pronounced (Dinan and Lim Rogers 2002; CBO 2003).
  - However, lower income households are still disproportionately impacted relative to higher income households.
- These analyses do not consider how expenditure patterns and demand for energy goods may change over time as a result of the policy. Furthermore, they do not always consider the effect of the policy on the prices of non-energy goods.
- Providing lump-sum compensation to households – or other economic entities – has an opportunity cost in the form of foregone efficiency gains.
  - The government cannot use the revenue to reduce other distortions in the economy, which would reduce the overall cost of the cap-and-trade policy (Fullerton forthcoming; CBO 2003).

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SR/OIAF/2009-05

Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009

August 2009

Energy Information Administration
Office of Integrated Analysis and Forecasting
U.S. Department of Energy
Washington, DC 20585

Preface and Contacts

The Energy Information Administration (EIA) is the independent statistical and analytical agency within the Department of Energy. EIA provides timely, high-quality energy information and prepares objective, transparent analyses for use by the Congress, the Administration, and the public. EIA does not, however, take positions on policy issues. Because of EIA's statutory independence with respect to the content of its energy information program, the analysis presented herein is strictly its own and should not be construed as representing the views of the U.S. Department of Energy or the Administration.

The model projections in this report are not statements of what *will* happen but of what *might* happen, given the assumptions and methodologies used. The Reference Case projections are business-as-usual trend forecasts, given known technology, technological and demographic trends, and current laws and regulations. Thus, they provide a policy-neutral starting point that can be used to analyze policy initiatives. EIA does not propose, advocate, or speculate on future legislative and regulatory changes. All laws are assumed to remain as currently enacted; however, the impacts of scheduled regulatory changes, when defined, are reflected.

The Office of Integrated Analysis and Forecasting prepared this report. General questions concerning the report can be directed to John J. Conti (john.conti@eia.doe.gov, 202/586-2222), Director of the Office of Integrated Analysis and Forecasting; J. Alan Beamon (joseph.beamon@eia.doe.gov, 202/586-2025), Director of its Coal and Electric Power Division; Michael Schaal (michael.schaal@eia.doe.gov, 202/586-5590, Director of its Oil and Natural Gas Division; Paul Holtberg (paul.holtberg@eia.doe.gov, 202/586-1284, Director of its Demand and Integration Division; Glen Sweetnam (glen.sweetnam@eia.doe.gov, 202/586-2188, Director of its International, Economic and Greenhouse Gases Division; and Andy S. Kydes (akydes@eia.doe.gov, 202/586-0883) Senior Technical Advisor to the Office Director. Specific questions about the report can be directed to the following analysts:

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Executive Summary

This report responds to a request to the Energy Information Administration (EIA) from Chairman Henry Waxman and Chairman Edward Markey for an analysis of H.R. 2454, the American Clean Energy and Security Act of 2009 (ACESA).[1] ACESA, as passed by the House of Representatives on June 26, 2009, is a complex bill that regulates emissions of greenhouse gases through market-based mechanisms, efficiency programs, and economic incentives.

The Title III cap-and-trade program for greenhouse gas (GHG) emissions, which covers roughly 84 percent of total U.S. GHG emissions by 2016, is in many respects the centerpiece of the bill and the primary driver of the results presented in this report. The program subjects covered emissions to a cap that declines steadily between 2012 and 2050. The cap requires a 17- percent reduction in covered emissions by 2020 and an 83-percent reduction by 2050, both relative to a 2005 baseline, with targets that decline steadily for intermediate years. Compliance is enforced through a requirement for entities subject to the cap to submit allowances, which are bankable, sufficient to cover their emissions. Allowance obligations may also be offset by reductions in domestic emissions of exempted sources, by international offsets, or by emission allowances from other countries with comparable laws limiting emissions. Maximum offsets from domestic and international sources are each capped separately at 1 billion metric tons (BMT) in each year of the program, with the proviso that up to 500 million metric tons (MMT) of the domestic offset cap may be shifted to the international offset cap if the Administrator of the Environmental Protection Agency (EPA) determines that a sufficient supply of domestic offsets is not available. In addition to its centerpiece cap-and-trade program, Title III also includes additional GHG standards, dedicated programs to limit hydrofluorocarbon (HFC) emissions and black carbon, and provisions governing markets in carbon-related derivatives.

Title I contains provisions related to a Federal combined efficiency and renewable electricity standard for electricity sellers, carbon capture and storage technology, performance standards for new coal-fueled power plants, research and development support for electric vehicles, support for deployment of a smart grid, and establishment of a Clean Energy Deployment Administration. Title II includes provisions related to building, lighting, appliance, and vehicle energy efficiency programs. Title IV includes provisions to preserve domestic competitiveness and support workers, provide assistance to consumers, and support domestic and international adaptation initiatives. Title V addresses the role of domestic agricultural and forestry-related offsets in the Title III cap-and-trade program.

This report considers the energy-related provisions in ACESA that can be analyzed using EIA's National Energy Modeling System (NEMS). The Reference Case used as the starting point for the analysis in this report is an updated version of the *Annual Energy Outlook 2009 (AEO2009)* Reference Case issued in April 2009 that reflects the projected impacts of the American Recovery and Reinvestment Act as well as other significant energy legislation, including the Energy Improvement and Extension Act of 2008, the Energy Independence and Security Act of 2007, and

[1] The request letter from Chairman Waxman and Chairman Markey is provided in Appendix A.

the Energy Policy Act of 2005[2]. Cumulative GHG emissions covered by the Title III cap-and-trade program over the 2012 to 2030 period are estimated to be 113.4 BMT in CO_2-equivalent terms.

Key provisions of ACESA that are represented in the policy cases developed in this analysis include[3]:

- the GHG cap-and-trade program for gases other than HFCs, including provisions for the allocation of allowances to electricity and natural gas distribution utilities, low-income consumers, State efficiency programs, rebate programs, energy-intensive industries, and other specified purposes;
- the combined efficiency and renewable electricity standard for electricity sellers;
- the carbon capture and storage (CCS) demonstration and early deployment program;
- Federal building code updates for both residential and commercial buildings;
- Federal efficiency standards for lighting and other appliances;
- technology improvements driven by the Centers for Energy and Environmental Knowledge and Outreach; and
- the smart grid peak savings program.

While this analysis is as comprehensive as possible given its timing, it does not address all the provisions of ACESA. Provisions that are not represented include the Clean Energy Deployment Administration, the strategic allowance reserve, the separate cap-and-trade program for HFC emissions, the GHG performance standards for activities not subject to the cap-and-trade program, the distribution of allowances to coal merchant plants, new efficiency standards for transportation equipment, and the effects of increased investment in energy research and development. Of these provisions, the Clean Energy Deployment Administration may have the most significant potential to alter the reported results.

Like other EIA analyses of energy and environmental policy proposals, this report focuses on the impacts of those proposals on energy choices made by consumers in all sectors and the implications of those decisions for the economy. This focus is consistent with EIA's statutory mission and expertise. The study does not account for any possible health or environmental benefits that might be associated with curtailing GHG emissions.

Finally, while the emissions caps in the ACESA cap-and-trade program decline through the year 2050, the modeling horizon in this report runs only through 2030, the projection limit of NEMS. As in EIA analyses of earlier cap-and-trade proposals, the need to pursue higher-cost emissions reductions beyond 2030, driven by tighter caps and continued economic and population growth, can

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[2] The development of the updated Reference Case is described in a recent EIA report, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, SR/OIAF/2009-03 (Washington, DC, April 2009), web site http://www.eia.doe.gov/oiaf/servicerpt/stimulus/index.html.

[3] Detailed descriptions of the assumptions used and changes made to the National Energy Modeling System to represent the provisions of the American Clean Energy and Security Act are provided in Appendix B.

be reflected in the modeling by assuming that a positive bank of allowances is held at the end of 2030 in all but one case.

Analysis Cases

EIA prepared a range of analysis cases for this report. The six main analysis cases discussed in this Executive Summary, while not exhaustive, focus on two key areas of uncertainty that impact the analysis results.

The role of offsets is a large area of uncertainty in any analysis of ACESA. The 2-BMT annual limit on total offsets in ACESA is equivalent to one-third of total energy-related GHG emissions in 2008 and represents nearly six times the projected growth in energy-related emissions through 2030 in the Reference Case used in this analysis.

While the ceiling on offset use is clear, their actual use is an open question. Beyond the usual uncertainties related to the technical, economic, and market supply of offsets, the future use of offsets for ACESA compliance also depends both on regulatory decisions that are yet to be made by the EPA, on the timing and scope of negotiations on international agreements or arrangements between the United States and countries where offset opportunities may exist, and on emissions reduction commitments made by other countries. Also, limits on offset use in ACESA apply individually to each covered entity, so that offset "capacity" that goes unused by one or more covered entities cannot be used by other covered entities. For some major entities covered by the cap-and-trade program, decisions regarding the use of offsets could potentially be affected by regulation at the State level. Given the many technical factors and implementation decisions involved, it is hardly surprising that analysts' estimates of international offset use span an extremely wide range. One recent analysis doubts that even 150 MMT of international offsets will be used by 2020, while another posits that 1 BMT of international offsets will be used almost immediately from the start of the program in 2012, followed by a quick rise towards an expanded 1.5-BMT ceiling shortly thereafter.

The other major area of uncertainty in assessing the energy system and economic impacts of ACESA involves the timing, cost, and public acceptance of low- and no-carbon technologies. For the period prior to 2030, the availability and cost of low- and no-carbon baseload electricity technologies, such as nuclear power and fossil (coal and natural gas) with CCS, which can potentially displace a large amount of conventional coal-fired generation, is a key issue. However, technology availability over an extended horizon is a two-sided issue. Research and development breakthroughs over the next two decades could expand the set of reasonably priced and scalable low- and no-carbon energy technologies across all energy uses, including transportation, with opportunities for widespread deployment beyond 2030. The achievement of significant near-term progress towards such an outcome, however, could significantly reduce the size of the bank of allowances that covered entities and other market participants would want to carry forward to meet compliance requirements beyond 2030.

With these key uncertainties in mind, the main analysis cases discussed in this report are as follows:

- The **ACESA Basic Case** represents an environment where key low-emissions technologies, including nuclear, fossil with CCS, and various renewables, are developed and deployed on a large scale in a timeframe consistent with the emissions reduction requirements of ACESA without encountering any major obstacles. It also assumes that the use of offsets, both domestic and international, is not severely constrained by cost, regulation, or the pace of negotiations with key countries covering key sectors. In anticipation of increasingly stringent caps and rising allowance prices after 2030, covered entities and investors are assumed to amass an aggregate allowance bank of approximately 13 BMT by 2030 through a combination of offset usage and emission reductions that exceed the level required under the emission caps.

- The **ACESA Zero Bank Case** is similar to the Basic Case except that no banked allowances are held in 2030, reflecting the assumed availability of a broad array of reasonably priced low- and no-carbon technologies that can provide an alternative path to compliance with tighter emissions caps after 2030 through reductions across all energy uses, including transportation.

- The **ACESA High Offsets Case** is similar to the Basic Case except that it assumes the near-immediate use of international offsets at levels at or close to the specified aggregate ceiling, without regard to possible institutional or market impediments.

- The **ACESA High Cost Case** is similar to the Basic Case except that the costs of nuclear, coal with CCS, and dedicated biomass generating technologies are assumed to be 50 percent higher.

- The **ACESA No International Case** is similar to the Basic Case, but represents an environment where the use of international offsets is severely limited by cost, regulation, and/or slow progress in reaching international agreements or arrangements covering offsets in key countries and sectors.

- The **ACESA No International/Limited Case** combines the treatment of offsets in the ACESA No International Case with an assumption that deployment of key technologies, including nuclear, fossil with CCS, and dedicated biomass, cannot expand beyond their Reference Case levels through 2030.[4]

The full report discusses a number of additional analysis cases, including an accelerated Corporate Average Fuel Efficiency (CAFE) standards (35CAFE2016) case that incorporates the acceleration in fuel economy standards for light-duty vehicles announced by the Administration in May 2009, a 5-percent discount case that adopts an alternative view of real escalation in allowance prices (Low Discount), a case with limitations to the penetration of nuclear, CCS, and biomass gasification capacity (Limited Alternatives), an accelerated energy technology (High Tech) case, and a higher level of allowance banking (High Banking) case.

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[4] This case was originally included in EIA's April 2008 analysis of the Lieberman-Warner Climate Security Act (S. 2191) pursuant to a request from Senators Barrasso, Inhofe, and Voinovich.

EIA cannot attach probabilities to the individual policy cases. However, both theory and common sense suggest that cases that reflect an unbroken chain of either failures or successes in a series of independent factors are inherently less likely than cases that do not assume that everything goes either wrong or right. In this respect, the No International/Limited and Zero Bank Cases might be viewed as more pessimistic and optimistic scenarios, respectively, which bracket a set of more likely cases. Similarly, if actual access to international offsets is dependent on a series of independent regulatory and negotiating outcomes, cases with intermediate access to international offsets might be viewed as more likely than those representing either complete and immediate success across the board (High Offsets), or a permanent lack of progress (No International) in such activities.

Key Findings

Given the potential of offsets as a low-cost compliance option, the amount of reduction in covered emissions is exceeded by the amount of compliance generated through offsets in most of the main analysis cases (Figure ES-1). Cumulative compliance between 2012 and 2030, including reductions both in domestic emissions of covered gases and in domestic and international offsets, ranges from 24.4 BMT to 37.6 BMT carbon dioxide (CO_2)-equivalent emissions in the main analysis cases, representing a 21-percent to 33-percent reduction from the level of cumulative covered emissions projected in the Reference Case.[5] In the ACESA Basic Case, domestic abatement of covered gases represents only 39 percent of cumulative compliance. In the ACESA High Offsets Case, where the maximum quantity of international offsets is used immediately at the start of the program in 2012, domestic abatement in covered gases accounts for just 22 percent of the cumulative compliance. Reductions in the emissions of energy-related CO_2 account for more than half of projected cumulative compliance through 2030 only in the cases where international offsets are not assumed to be available.

The vast majority of reductions in energy-related emissions are expected to occur in the electric power sector. Across the ACESA main cases, the electricity sector accounts for between 80 percent and 88 percent of the total reduction in energy-related CO_2 emissions relative to the Reference Case in 2030. Reductions in electricity-sector emissions are primarily achieved by reducing the role of conventional coal-fired generation, which in 2007 provided 50 percent of total U.S. generation, and increasing the use of no- or low-carbon generation technologies that either exist today (e.g. renewables and nuclear) or are under development (fossil with CCS). In addition, a portion of the electricity-related CO_2 emissions reductions results from reduced electricity demand stimulated both by consumer responses to higher electricity prices and incentives in ACESA to stimulate greater efficiency in energy use.

If new nuclear, renewable, and fossil plants with CCS are not developed and deployed in a timeframe consistent with emissions reduction requirements under ACESA, covered entities are expected to respond by increasing their use of offsets, if available, and by turning to increased natural gas use to offset reductions in coal generation. While natural gas generation is expected to fall below the Reference Case level in most ACESA Cases, in the ACESA No International/Limited Case natural gas generation is 68 percent above the Reference Case level by

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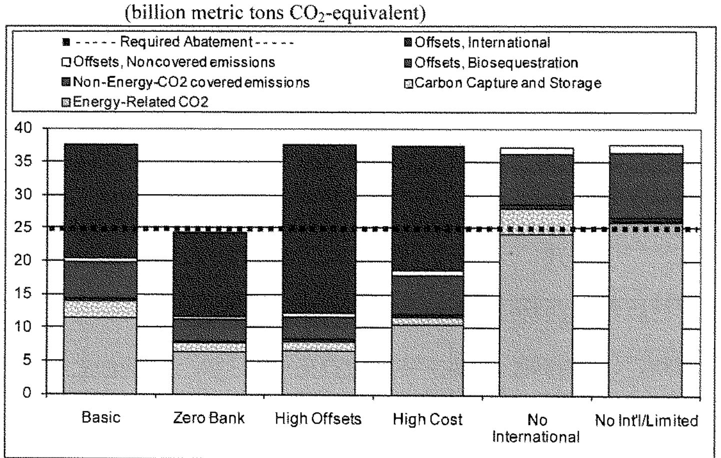
[5] This overall compliance level includes both the projected cumulative 24.6–BMT-difference between the Reference Case projection and the ACESA cap on covered CO_2-equivalent emissions between 2012 and 2030 and the accumulation of an additional 13 BMT in allowances that are banked for use in post-2030 compliance.

2030, due to the assumed limited availability of international offsets, new plants with CCS, as well as new nuclear and dedicated biomass capacity (Table ES-1).

Figure ES-1. Components of Cumulative Compliance in ACESA Main Cases, 2012-2030
(billion metric tons CO_2-equivalent)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Emissions reductions from changes in fossil fuel use in the residential, commercial, industrial and transportation sectors are small relative to those in the electric power sector. Taken together, changes in fossil fuel use in these sectors account for between 12 percent and 20 percent of the total reduction in energy-related CO_2 emissions relative to the Reference Case in 2030, reflecting both lesser percentage changes in delivered fossil fuel prices than experienced by the electricity generation sector and the low availability of alternatives in many applications (Figure ES-2). For example, motor gasoline prices in the ACESA Basic Case are only 20 cents per gallon higher than in the Reference Case in 2020 and 35 cents per gallon higher in 2030 (in 2007 dollars). In addition, since all cases include the 35-mile-per-gallon CAFE standard enacted in the Energy Independence and Security Act of 2007, many of the most cost-effective vehicle efficiency options are adopted in all cases, including the Reference Case. Beyond reductions in direct fuel use, the reduction in electricity demand, which ranges from 4.1 percent to 14.7 percent below the Reference Case level in 2030 across the main policy cases, makes an important contribution to the overall reduction in electricity-related emissions.

Table ES-1. Summary Results

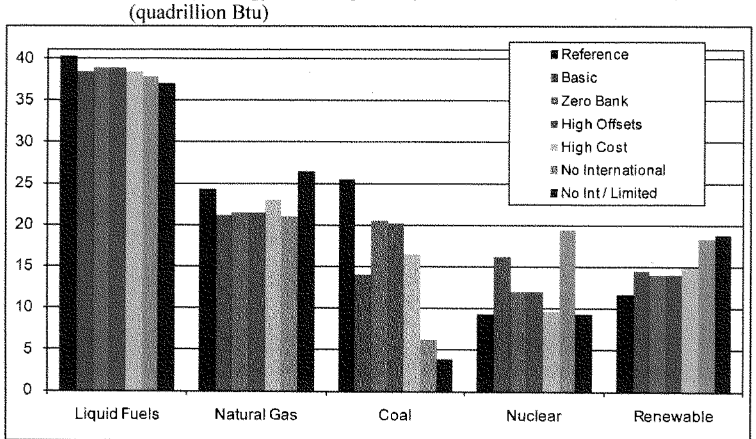
	2007	2020							2030						
			ACESA Cases							ACESA Cases					
		Reference	Basic	Zero Bank	High Offsets	High Cost	No International Offsets	No International / Limited	Reference	Basic	Zero Bank	High Offsets	High Cost	No International Offsets	No International / Limited
Greenhouse gas emissions (mmt)															
Covered emissions															
Energy-related carbon dioxide	4948	5910	5355	5560	5553	5417	4691	4655	6212	4408	5286	5233	4883	3626	4041
Other covered emissions	167	171	150	152	152	149	148	146	177	152	153	154	152	150	146
Total covered emissions	5114	6081	5505	5712	5705	5566	4839	4801	6389	4560	5440	5387	5034	3776	4187
Noncovered emissions	2242	1411	1368	1401	1400	1385	1377	1358	1665	1624	1634	1633	1613	1604	1599
Total greenhouse gas emissions	7357	7492	6893	7113	7105	6951	6216	6158	8054	6184	7074	7020	6647	5380	5786
Offset credits (mmt)															
Noncovered gases	0	0	35	22	23	38	46	65	0	53	43	44	64	73	78
Biogenic sequestration	0	0	251	155	161	278	385	515	0	448	292	301	481	596	676
Total domestic offset credits	0	0	286	177	183	315	431	580	0	501	335	345	545	669	754
International offset credits (post exchange)	0	0	966	135	1305	1272	0	0	0	1320	1479	1470	1361	0	0
Total domestic and international	0	0	1252	312	1488	1587	431	580	0	1821	1814	1814	1906	669	754
Total emissions net of biosequestration and international reductions (mmt)	7357	7492	5435	6789	5313	5084	5831	5643	8054	4086	4932	4882	4465	4784	5109
Cap and trade compliance summary (mmt)															
Allowances issued (cap)	n.a	5086	5086	5086	5088	5086	5086	5086	3554	3554	3554	3554	3554	3554	3554
Covered emissions, less offset credits	5114	6081	4254	5400	4217	3979	4409	4221	6389	2739	3825	3573	3128	3107	3433
Net allowance bank change	0	0	833	-313	870	1107	678	866	0	815	-71	-18	428	447	122
Allowance bank balance	0	0	4616	-930	10122	6221	6033	8720	0	13085	-35	13069	13040	12774	13186
Allowance and offset prices (2007 dollars per metric ton CO2 equivalent)															
Emission allowance	0.0	0.0	31.7	19.9	20.5	35.4	52.1	93.3	0.0	64.8	40.6	41.9	72.2	106.4	190.5
Domestic offset	0.0	0.0	31.7	19.9	20.5	35.4	52.1	93.3	0.0	64.8	40.6	41.9	72.2	106.4	134.0
International offset	0.0	0.0	25.4	15.9	16.4	28.3	41.7	74.6	0.0	22.6	23.3	33.5	22.8	85.1	152.4
Delivered energy prices (including allowance cost after adjustment for free allocations) (2007 dollars per unit indicated)															
Motor gasoline, transport (per gallon)	2.82	3.62	3.82	3.74	3.74	3.64	3.97	4.29	3.82	4.17	4.02	4.03	4.31	4.51	5.10
Jet fuel (per gallon)	2.17	3.02	3.26	3.18	3.18	3.32	3.48	3.85	3.33	3.80	3.58	3.59	3.85	4.18	4.97
Diesel (per gallon)	2.87	3.64	3.90	3.79	3.79	3.92	4.06	4.48	3.88	4.36	4.13	4.15	4.44	4.75	5.61
Natural gas (per thousand cubic feet)															
Residential	13.05	12.91	13.27	13.07	13.10	13.59	13.72	15.91	14.35	16.61	15.49	15.51	18.00	19.06	25.17
Electric power	7.22	7.22	8.52	7.93	8.00	9.08	9.85	13.89	8.57	10.44	9.18	9.20	11.84	12.72	19.49
Coal, electric power sector (per million Btu)	1.78	1.96	4.84	3.76	3.82	5.18	6.60	10.47	2.04	7.82	5.71	5.83	8.64	11.49	19.38
Electricity (cents per kilowatthour)	9.10	9.27	9.51	9.51	9.55	9.65	9.59	10.69	10.05	12.01	11.08	11.12	12.98	12.69	17.83
Energy consumption (quadrillion Btu)															
Liquid fuels	40.8	38.7	37.5	37.7	37.8	37.6	37.3	37.0	40.3	38.3	38.9	38.9	38.4	37.7	37.0
Natural gas	23.7	22.1	21.5	21.6	21.6	22.0	21.5	25.4	24.2	21.1	21.4	21.5	23.0	21.0	26.5
Coal	22.7	24.4	20.6	22.0	21.9	20.2	14.4	10.5	25.4	14.0	20.5	20.2	16.5	6.2	3.9
Nuclear power	8.4	9.1	9.8	9.4	9.4	9.1	10.6	9.1	9.3	16.2	12.0	12.0	9.6	19.4	9.3
Renewable/Other	6.3	10.4	12.2	11.4	11.5	12.5	17.0	15.3	11.8	14.9	14.1	14.2	15.5	18.8	19.3
Total	101.9	104.7	101.6	102.1	102.1	101.3	100.8	97.5	111.0	104.5	106.8	106.7	103.0	103.2	96.0
Purchased electricity	12.8	14.1	13.8	13.8	13.8	13.7	13.7	13.3	15.4	14.5	14.7	14.7	14.2	14.3	13.0
Electricity generation (billion kilowatthours)															
Petroleum	66	49	46	47	48	47	44	45	50	43	46	46	45	41	43
Natural gas	892	714	694	696	704	770	700	1320	976	704	717	721	1040	739	1638
Coal	2021	2198	1875	2003	1987	1833	1309	943	2311	1354	1912	1897	1574	540	300
Nuclear power	806	876	940	904	904	869	1018	876	890	1548	1147	1151	923	1863	890
Renewable/Other	374	736	907	832	837	930	1364	1118	827	1048	1007	1015	1004	1426	1346
Total	4159	4573	4462	4481	4479	4449	4436	4303	5055	4697	4830	4829	4587	4608	4216

mmt: million metric tons of carbon dioxide equivalent

Source: National Energy Modeling System, runs STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A

Note: 2007 total covered emissions reflect the coverage of H.R. 2454 as defined in 2012.

Figure ES-2. Primary Energy Consumption by Fuel in Main ACESA Cases, 2030
(quadrillion Btu)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

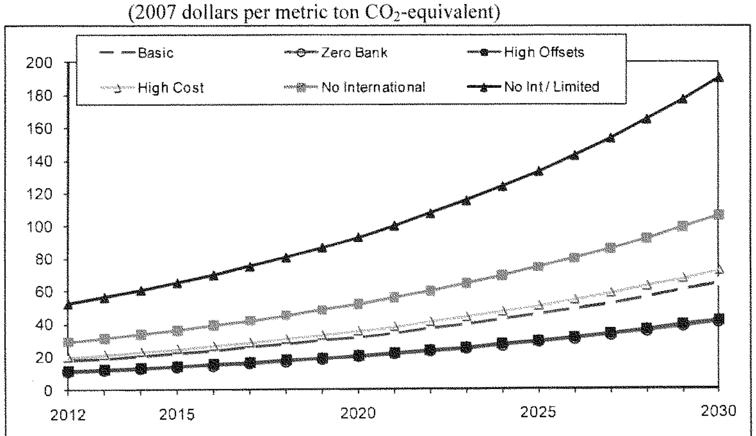
GHG allowance prices are sensitive to the cost and availability of emissions offsets and low-and no-carbon generating technologies. Allowance prices in the ACESA Basic Case are projected at $32 per metric ton in 2020 and $65 per metric ton in 2030. Across all main analysis cases, allowance prices range from $20 to $93 per metric ton in 2020 and from $41 to $191 (2007 dollars) per metric ton in 2030 (Figure ES-3). The lower prices in the range occur in cases where technological options such as CCS and adoption of new nuclear power plants can be deployed on a large scale before 2030 at relatively low costs, the use of international offsets helps to hold down compliance costs, and/or optimism about future technology availability holds down the near-term incentive to bank allowances for use beyond 2030 (ACESA Basic, ACESA High Offset, and/or ACESA Zero Bank cases). Higher allowance prices occur if international offsets are unavailable, particularly if it is also the case that low- or no-emission baseload electricity supply technologies cannot be expanded beyond the Reference Case level (ACESA No International and ACESA No International/Limited cases).

ACESA increases energy prices, but effects on electricity and natural gas bills of consumers are substantially mitigated through 2025 by the allocation of free allowances to regulated electricity and natural gas distribution companies. Except for the ACESA No International/Limited Case, electricity prices in five of the six main ACESA cases range from 9.5 to 9.6 cents per kilowatthour in 2020, only 3 to 4 percent above the Reference Case level.[6] Average impacts on electricity prices in 2030 are projected to be substantially greater, reflecting both higher allowance prices and the phase-out of the free allocation of allowances to distributors between 2025

[6] The average electricity price in the No International/Limited case in 2020 is 10.7 cents per kilowatthour.

and 2030. By 2030, electricity prices in the ACESA Basic Case are 12.0 cents per kilowatthour, 19 percent above the Reference Case level, with a wider band of 11.1 cents to 17.8 cents (10 to 77 percent above the Reference Case level) across all six main policy cases.

Figure ES-3. Allowance Prices in Main ACESA Cases, 2012-2030
(2007 dollars per metric ton CO_2-equivalent)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

ACESA increases the cost of using energy, which reduces real economic output, reduces purchasing power, and lowers aggregate demand for goods and services. The result is that projected real gross domestic product (GDP) generally falls relative to the Reference Case. Total discounted GDP losses over the 2012 to 2030 time period are $566 billion (-0.3 percent) in the ACESA Basic Case, with a range from $432 billion (-0.2 percent) to $1,897 billion (-0.9 percent) across the main ACESA cases (Table ES-2). Similarly, the cumulative discounted losses for personal consumption are $273 billion (-0.2 percent) in the ACESA Basic Case and range from $196 billion (-0.1 percent) to $988 billion (-0.7 percent). GDP losses in 2030, the last year explicitly modeled in this analysis, range from $104 billion to $453 billion (-0.5 to -2.3 percent), while consumption losses in that year range from $36 billion to $180 billion (-0.3 to -1.3 percent). The estimated 2030 GDP and consumption losses in the ACESA No International/Limited Case, at the top of these ranges, are nearly or more than twice as large as those in the ACESA No International and High Cost Cases, which have the next highest level of impacts.

Consumption and energy bill impacts can also be expressed on a per household basis in particular years. In 2020, the reduction in household consumption is $134 (2007 dollars) in the ACESA Basic Case, with a range of $30 to $362 across all main ACESA cases. In 2030, household consumption is reduced by $339 in the ACESA Basic Case, with a range of $157 to $850 per household across all main ACESA cases. By 2030, the estimated reductions in household consumption in the ACESA No International/Limited Case, at the top of these ranges, are approximately double the impacts in the ACESA High Cost Case, which has the next highest level of impacts.

Table ES-2. Macroeconomic Impacts of ACESA Cases Relative to the Reference Case
(billion 2000 dollars, except where noted)

	Basic	Zero Bank	High Offsets	High Cost	No International	No Int / Limited
Cumulative Real Impacts 2012-2030 (present value using 4-percent discount rate)						
GDP						
Change	-566	-432	-523	-781	-717	-1897
Percent Change	-0.3%	-0.2%	-0.2%	-0.4%	-0.3%	-0.9%
Consumption						
Change	-273	-196	-252	-384	-323	-988
Percent Change	-0.2%	-0.1%	-0.2%	-0.3%	-0.2%	-0.7%
Industrial Shipments (excludes services)						
Change	-910	-753	-480	-958	-1720	-2877
Percent Change	-1.0%	-0.8%	-0.5%	-1.1%	-1.9%	-3.2%
Nominal Revenue Collected 2012-2030[a]	2971	1292	1332	2299	3462	6350
2020 Impacts (not discounted)						
GDP						
Change	-50	-19	-26	-70	-34	-112
Percent Change	-0.3%	-0.1%	-0.2%	-0.5%	-0.2%	-0.7%
Consumption						
Change	-21	-7	-11	-30	-15	-64
Percent Change	-0.2%	-0.1%	-0.1%	-0.3%	-0.1%	-0.6%
Industrial Shipments (excludes services)						
Change	-68	-54	-32	-69	-108	-186
Percent Change	-1.0%	-0.8%	-0.5%	-1.0%	-1.6%	-2.8%
Nominal Revenue Collected[a]	71	44	46	79	118	215
2030 Impacts (not discounted)						
GDP						
Change	-161	-104	-120	-214	-226	-453
Percent Change	-0.8%	-0.5%	-0.6%	-1.1%	-1.1%	-2.3%
Consumption						
Change	-63	-36	-50	-97	-69	-180
Percent Change	-0.4%	-0.3%	-0.4%	-0.7%	-0.5%	-1.3%
Industrial Shipments (excludes services)						
Change	-183	-125	-87	-198	-338	-506
Percent Change	-2.5%	-1.7%	-1.2%	-2.7%	-4.6%	-6.8%
Nominal Revenue Collected[a]	330	205	211	367	556	1030

[a] Includes revenues from allowance auctions and revenues generated by the resale of allowances distributed to non-emitters. These values are not discounted.
Note: All changes shown are relative to the updated *AEO2009* Reference Case.
Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

The free allocation of output-based allowances reduces the impact of ACESA on energy-intensive, trade- vulnerable industries. Receiving free allowances in proportion to output softens the impacts of increased energy prices on these industries. As a result, when energy prices increase under ACESA, the reductions in output of these trade- and energy-vulnerable industries are less than overall manufacturing impacts and mirror the impacts of total industrial shipments. The discounted cumulative percent losses of energy-intensive industrial output range from -0.5 percent to -3.6 percent from 2012-2030 compared to manufacturing losses of -0.5 percent to -4.3 percent.

Additional Insights

The role of baseline assumptions. The choice of a baseline is one of the most influential assumptions for any analysis of global climate change legislation. This analysis uses the updated Reference Case of the *AEO2009* as a starting point. These projections and our analysis are not meant to be exact predictions of the future but represent plausible energy futures given technological and demographic trends, current laws and regulations, and consumer behavior as derived from available data. EIA recognizes that projections of energy markets over a nearly 25-year period are highly uncertain and subject to many events that cannot be foreseen, such as supply disruptions, policy changes, and technological breakthroughs. In addition to these phenomena, long-term trends in technology development, demographics, economic growth, and energy resources may evolve along a different path than expected in the projections. Generally, differences between cases, which are the focus of our report, are likely to be more robust than the specific projections for any one case. The published *AEO2009*, which includes numerous cases reflecting a variety of alternative futures for the economy, energy markets, and technology, is a resource that can be used to examine the implications of alternative baselines.

The strategic allowance reserve. The strategic allowance reserve, which focuses on the important issue of short-term volatility in allowance prices, is not addressed in this analysis. As currently structured, the strategic allowance reserve, following a startup period, relies on a "trigger price" for auctions that is set in relation to recent allowance prices. Such an approach does not appear to preclude a scenario in which allowance prices evolve along a "high" trajectory given underlying conditions that would support such an outcome, such as those examined in the No International and No International/Limited cases. Also, the strategic allowance reserve, in contrast to other cost-containment mechanisms that more directly tie compliance pressure to the level of compliance costs or other measures of economic impact, would be unlikely to discourage stakeholders who view GHG emissions limitation as the highest environmental protection priority from pursuing efforts to block the deployment of nuclear power, CCS, or other technologies that, from their perspective, may raise important, but lesser, concerns. Therefore, as discussed in earlier EIA analyses, decisions regarding the design of a cost-containment mechanism can affect the public acceptance of key low- and no-carbon technologies that may be part of a cost-effective compliance mix.

Free allowance allocation to electricity and natural gas distributors. The analysis shows that the free allocation of allowances to electricity and natural gas distributors significantly ameliorates impacts on consumer electricity and natural gas prices prior to 2025, when it starts to be phased out. While this result may serve goals related to regional and overall fairness of the program, the overall efficiency of the cap-and-trade program is reduced to the extent that the price signal that would encourage cost-effective changes by consumers in their use of electricity and natural gas is delayed.

Electricity capacity siting challenges. Besides changing the projected mix of new electricity generation capacity, compliance with ACESA will also significantly increase the total amount of new electric capacity that must be added between now and 2030 due to the retirement of many existing coal-fired power plants that otherwise would be expected to continue operating beyond 2030. Obstacles to siting major electricity generation projects and/or the transmission facilities needed to support the greatly expanded use of renewable energy sources are not explicitly considered in this report. However, the additional capacity needs in all of the ACESA cases suggest the need for review of siting processes so that they will be able to support a large-scale transformation of the Nation's electricity infrastructure by 2030.

Challenges beyond 2030. As previously noted, the modeling horizon for this analysis ends in 2030. Unless substantial progress is made in identifying low- and no-carbon technologies outside of electricity generation, the ACESA emissions targets for the 2030-to-2050 period are likely to be very challenging as opportunities for further reductions in power sector emissions are exhausted and reductions in other sectors are thought to be more expensive.

Background and Scope of the Analysis

Background

This report responds to a request from Chairman Henry Waxman and Chairman Edward Markey for an analysis of H.R. 2454, the American Clean Energy and Security Act of 2009 (ACESA).[7] ACESA, as passed by the U.S. House of Representatives on June 26, 2009, is a complex bill that regulates emissions of greenhouse gases (GHGs) through a variety of market-based mechanisms, efficiency programs, and economic incentives. The bill includes four titles designed to spur clean energy development, increase investment in energy efficiency, reduce global warming pollution, and transition to a clean energy economy.

Clean Energy

Title I of H.R. 2454 focuses primarily on the development of clean energy resources. It establishes a combined efficiency and renewable electricity standard (CERES) requiring that all retail electricity suppliers with annual sales above 4 million megawatthours meet 20 percent of their load with qualified renewable energy sources or electricity efficiency savings by 2020. One-fifth of the requirement can initially be met with efficiency savings, with the possibility of an additional 20 percent if approved by the Federal Energy Regulatory Commission.

Title I also includes provisions to spur the commercialization of carbon capture and storage (CCS) technology, encourage increased investment in energy efficiency through allowance distributions to States, stimulate reductions in peak electricity loads, and motivate investment in an electric vehicle infrastructure. In addition, it establishes a Clean Energy Deployment Administration to promote the domestic development and deployment of clean energy technologies, including advanced or enabling infrastructure technologies, energy efficiency technologies, and related manufacturing technologies, through partnership with and support of the private capital market.

Energy Efficiency

Title II of H.R. 2454 focuses on improving energy efficiency. It requires revisions to building codes for both new construction and existing facilities. It provides financial assistance for efficiency retrofit projects in existing buildings and calls for the development of new efficiency standards for several lighting and appliance applications, such as street lights, parking lot lights, portable light fixtures, hot food holding cabinets, bottle-type drinking water dispensers, commercial grade natural gas furnaces, and portable spas (hot tubs).

In order to address transportation efficiency, Title II directs the Environmental Protection Agency (EPA) and the Department of Transportation (DOT) to set GHG emission standards for heavy highway vehicles, non-road vehicles, and aircraft. It requires States to develop transportation GHG reduction plans and calls for EPA to expand its fuel-saving technologies deployment program. The Department of Energy (DOE) is also directed to establish further

[7] The request letter from Chairman Waxman and Chairman Markey is provided in Appendix A.

standards for industrial energy efficiency, create an awards program for increasing efficiency in the thermal electricity generation process, and clarify the waste-to-heat energy incentives in the Energy Independence and Security Act of 2007 (EISA 2007).

Reducing Global Warming Pollution

Title III of H.R. 2454 focuses on reducing GHG emissions by establishing a cap on emissions beginning in 2012 that covers electricity generators, liquid fuel refiners and importers, and fluorinated gas manufacturers. In 2014, the cap is expanded to include industrial sources that emit greater than 25,000 tons of carbon dioxide-(CO_2) equivalent emissions, and in 2016 it is further expanded to include retail natural gas distribution companies. Relative to their emissions in 2005, covered sources must reduce their emissions 3 percent by 2012, 17 percent by 2020, 58 percent by 2030, and 83 percent by 2050. It provides for unlimited banking of allowances, while borrowing future allowances to meet current compliance obligations is allowed with some restrictions.

Title III also allows covered entities to offset up to 2 billion metric tons (BMT) of CO_2-equivalent emissions through the use of domestic and international offsets. The offset limits are applied on a pro-rata basis to individual covered entities. The annual percentage of offsets a covered entity can use to comply with its limit is determined by dividing 2 billion by the sum of 2 billion and the number of allowances issued for the previous year. The pro-rata limit can therefore restrict offset usage independently of the overall 2-BMT limit. Under the overall limit, the title allows 1 BMT of international offsets and 1 BMT of domestic offsets. Furthermore, beginning in 2018, five international offsets must be submitted to account for four allowances. As with the overall limit, domestic and international offsets under the pro-rata limit can each be no more than half the total. However, if the EPA Administrator expects the availability of domestic offset credits to be less than 900 million metric tons (MMT), given expected allowance prices, then the maximum percentage of international offsets is increased to reflect an amount equal to 1,000 MMT less the expected domestic offset availability, up to 500 MMT. International allowances can also be used for compliance, provided that they originate from a program with mandatory emissions reductions and have not been used already to comply with another program. The authority to designate a limit on the use of international allowances is granted to EPA. Title V addresses the role of domestic agricultural and forestry-related offsets in the Title III cap-and-trade program.

Transitioning to Clean Energy Economy

Title IV of H.R. 2454 includes provisions intended to mitigate adverse economic impacts caused by the provisions of Title III. It directs EPA to provide rebates for industrial facilities that it determines face significant additional costs as a result of Title III. It also authorizes tax credits and refunds for low income energy consumers, in order to compensate them for any losses in purchasing power due to higher energy costs and provides for financial assistance to workers who loose their job as a result of the Title III program. In addition, it authorizes an increase in grants for colleges and universities that are developing programs in clean energy technology and energy efficiency.

Representing H.R. 2454 in the National Energy Modeling System[8]

The analysis of energy sector and energy-related economic impacts of the various GHG emission reduction proposals in this report is based on results from the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). NEMS projects emissions of energy-related CO_2 emissions resulting from the combustion of fossil fuels, representing about 84 percent of total U.S. GHG emissions today. The emissions in NEMS account for the vast majority of total emissions covered by the main ACESA cap-and-trade program.

The Reference Case used in this report was published in a recent EIA report, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook.*[9] The Reference Case is designed to reflect only current laws and policies, so it explicitly avoids assumptions about "expected" policy changes such as future fuel economy standards, taxes, or new regulatory requirements for conventional pollutants or GHGs. For this reason, EIA Reference Case projections are not directly comparable with private energy forecasts that include estimates of policy change in their baseline scenarios.

NEMS endogenously calculates changes in energy-related CO_2 emissions in the analysis cases. The cost of using each fossil fuel includes the costs associated with the GHG allowances needed to cover the emissions produced when they are used. These adjustments influence energy demand and energy-related CO_2 emissions. The GHG allowance price also determines the reductions in projected baseline emissions of other GHGs based on assumed abatement cost relationships. With emission allowance banking, NEMS solves for the time path of permit prices such that cumulative emissions match the cumulative emissions target with price escalation consistent with the average cost of capital to the electric power sector.

The NEMS Macroeconomic Activity Module (MAM), which is based on the IHS Global Insight U.S. Model, interacts with the energy supply, demand, and conversion modules of NEMS to solve for an energy-economy equilibrium. In an iterative process within NEMS, MAM reacts to changes in energy prices, energy consumption, and allowance revenues, solving for the effect on macroeconomic and industry level variables such as real gross domestic product (GDP), the unemployment rate, inflation, and real industrial output.

Key provisions of ACESA that are represented in the policy cases developed in this analysis include:

- the cap-and-trade program for GHGs other than hydrofluorocarbons (HFCs), including provisions for the allocation of allowances to electricity and natural gas distribution utilities, low-income consumers, State efficiency programs, rebate programs, energy-intensive industries, and other specified purposes,
- the combined efficiency and renewable electricity standard for electricity sellers,

[8] Detailed discussion of the changes made to the NEMS to represent ACESA is provided in Appendix B.

[9] Energy Information Administration, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, SR/OIAF/2009-03 (Washington, DC, April 2009), http://www.eia.doe.gov/oiaf/servicerpt/stimulus/index.html.

- the CCS demonstration and early deployment program,
- Federal building code updates for both residential and commercial buildings,
- Federal efficiency standards for lighting and other appliances,
- technology improvements driven by the Centers for Energy and Environmental Knowledge and Outreach, and
- the smart grid peak savings program.

While this analysis is as comprehensive as possible given its timing, it does not address all the provisions of ACESA. Provisions that are not represented include the Clean Energy Deployment Administration, the strategic allowance reserve, the separate cap-and-trade program for HFC emissions, the GHG performance standards for activities not subject to the cap-and-trade program, the distribution of allowances to coal merchant plants, new efficiency standards for transportation equipment, and the effects of increased investment in energy research and development. Of these provisions, the Clean Energy Deployment Administration may have the most significant potential to alter the reported results.

Like other EIA analyses of energy and environmental policy proposals, this report focuses on the impacts of those proposals on energy choices made by consumers in all sectors and the implications of those decisions for the economy. This focus is consistent with EIA's statutory mission and expertise. The study does not account for any possible health or environmental benefits that might be associated with curtailing GHG emissions.

Finally, while the emissions caps in the ACESA cap-and-trade program decline through the year 2050, the modeling horizon in this report runs only through 2030, the projection limit of NEMS. As in EIA analyses of earlier cap-and-trade proposals, the need to pursue higher-cost emissions reductions beyond 2030, driven by tighter caps and continued economic and population growth, can be reflected in the modeling by assuming that a positive bank of allowances is held at the end of 2030 in all but one case.

Analysis Cases

Because of the complex interactions of the various policy instruments called for in ACESA, a large number of cases were prepared. These cases, while not exhaustive, are meant to explore key areas of uncertainty that impact the analysis results.

The role of offsets is a large area of uncertainty in any analysis of ACESA. The 2-BMT annual limit on total offsets in ACESA is equivalent to one-third of total energy-related GHG emissions in 2008 and represents nearly six times the projected growth in energy-related emissions through 2030 in the Reference Case used in this analysis.

While the ceiling on offset use is clear, their actual use is an open question. Beyond the usual uncertainties related to the technical, economic, and market supply of offsets, the future use of offsets for ACESA compliance also depends both on regulatory decisions that are yet to be made by the EPA, on the timing and scope of negotiations on international agreements or arrangements between the United States and countries where offset opportunities may exist, and on emissions reduction commitments made by other countries. Also, limits on offset use in ACESA apply individually to each covered entity, so that offset "capacity" that goes unused by one or more covered entities cannot be used by other covered entities. For some major entities covered by the cap-and-trade program, decisions regarding the use of offsets could potentially be affected by regulation at the State level. Given the many technical factors and implementation decisions involved, it is hardly surprising that analysts' estimates of international offset use span an extremely wide range. One recent analysis doubts that even 150 MMT of international offsets will be used by 2020, while another posits that 1 BMT of international offsets will be used almost immediately from the start of the program in 2012, followed by a quick rise towards an expanded 1.5-BMT ceiling shortly thereafter.

The other major area of uncertainty in assessing the energy system and economic impacts of ACESA involves the timing, cost, and public acceptance of low- and no-carbon technologies. For the period prior to 2030, the availability and cost of low- and no-carbon baseload electricity technologies, such as nuclear power and fossil (coal and natural gas) with CCS, which can potentially displace a large amount of conventional coal-fired generation, is a key issue. However, technology availability over an extended horizon is a two-sided issue. Research and development breakthroughs over the next two decades could expand the set of reasonably priced and scalable low- and no-carbon energy technologies across all energy uses, including transportation, with opportunities for widespread deployment beyond 2030. The achievement of significant near-term progress towards such an outcome, however, could significantly reduce the size of the bank of allowances that covered entities and other market participants would want to carry forward to meet compliance requirements beyond 2030.

Main Analysis Cases

- The **ACESA Basic Case** represents an environment where key low-emissions technologies, including nuclear, fossil with CCS, and various renewables, are developed and deployed on a large scale in a timeframe consistent with the emissions reduction requirements of ACESA without encountering any major obstacles. It also assumes that the use of offsets, both domestic and international, is not overly constrained by cost, regulation, or the pace of negotiations with key countries covering key sectors. In anticipation of increasingly stringent caps and rising allowance prices after 2030, covered entities and investors are assumed to amass an aggregate allowance bank of approximately 13 billion metric tons by 2030 through a combination of offset usage and emission reductions that exceed the level required under the emission caps.
- The **ACESA Zero Bank Case** is similar to the ACESA Basic Case but assumes that there is no accumulation of excess allowances for use beyond 2030. Instead, over the period 2012 to 2030 the cumulative covered emissions net of offsets are assumed to match the cumulative quantity of allowances issued, leaving an approximate zero balance in 2030. This scenario might occur if allowance prices were widely expected to stabilize or drop off after 2030, limiting the financial incentives to accumulate and hold allowances. This would imply the availability of a broad array of reasonably priced low- and no-carbon technologies that can

provide an alternative path to compliance with tighter emissions caps after 2030 through reductions across all energy uses, including transportation.

- The **ACESA High Offsets Case** is similar to the ACESA Basic Case except that it assumes that covered entities use the maximum allowable amount of international offsets beginning in 2012, with such offsets available at prices competitive with allowances and the necessary bilateral agreements in place with the supplying countries. This case illustrates the potential impacts where greater use of international compliance options reduces the share of emissions reduction requirements that must be met domestically. In the ACESA Basic Case and other cases, it is assumed that international offsets will penetrate the U.S. market more gradually.
- The **ACESA High Cost Case** is similar to the ACESA Basic Case except that the costs of nuclear, fossil with CCS, and biomass generating technologies are assumed to be 50 percent higher. There is great uncertainty about the costs of these technologies, as well as the feasibility of introducing them rapidly on a large scale. Cost estimates for these technologies rose rapidly from 2000 through 2008 and have only recently begun to moderate. The actual costs of these technologies will not become clearer until a number of full-scale projects are constructed and brought on line.
- The **ACESA No International Case** is similar to the ACESA Basic Case but represents an environment where the use of international offsets is severely limited by cost, regulation, and/or slow progress in reaching international agreements or arrangements covering offsets in key countries and sectors. The regulations that will govern the use of offsets have yet to be developed and their availability will depend on actions taken in the United States and around the world. It is possible that some significant portion of the potential international offsets will not be able to meet all of the requirements set forth in ACESA or, in meeting them, will make them uneconomical.
- The **ACESA No International/Limited Case** combines the treatment of offsets in the ACESA No International Case with an assumption that deployment of key technologies, including nuclear, fossil with CCS, and dedicated biomass, cannot expand beyond their Reference Case levels through 2030. There is great uncertainty about how fast these technologies, the industries that support them, and the regulatory infrastructure that licenses/permits them might be able to grow and, for fossil with CCS, when the technology will be fully commercialized. For nuclear, this assumption limits new plant additions to roughly 11,000 megawatts, or 7 to 11 new generators, by 2030. For fossil with CCS, this assumption limits new plant additions to 2,000 megawatts of demonstration projects or roughly 4 to 8 commercial-sized plants.

Additional Analysis Cases

- The **ACESA High Tech Case** is similar to the ACESA Basic Case except that it incorporates the technology assumptions from the Integrated High Technology Case published in the *Annual Energy Outlook 2009* (*AEO2009*). This case illustrates the impact of more aggressive assumptions about technological improvements and their role in reducing GHG emissions.
- The **ACESA Low Discount Case** is similar to the ACESA Basic Case except that it assumes a 5-percent discount rate for allowance-banking decisions. There is significant uncertainty about how the market for allowances will evolve and what rate of return investors in

allowances will require in order to hold allowance balances in anticipation of future higher compliance costs.

- The **ACESA 35CAFE2016 Case** is similar to the ACESA Basic Case except that it also incorporates an accelerated schedule for raising the combined fuel economy standards for cars and light trucks to 35 miles per gallon in 2016, as announced by the White House in May 2009.
- The **ACESA High Banking Case** similar to the ACESA Basic Case but assumes a greater level of allowances is banked from 2012 through 2030 and that covered entities and investors accumulate a 20-BMT allowance bank by 2030. Such a scenario could occur if widespread expectations of rising allowance prices spur market participants to make greater use of offsets and invest more heavily in emissions reduction opportunities early on, thus banking allowances for sale in the future.
- The **ACESA Limited Alternatives Case** represents an environment where the deployment of key technologies, including nuclear, fossil with CCS, and biomass, is limited to their Reference Case levels through 2030. There is great uncertainty about how fast these technologies, the industries that support them, and the regulatory infrastructure that license/permit them might be able to grow and, for fossil with CCS, when the technology will be fully commercialized. For nuclear, this assumption limits new plant additions to roughly 11,000 megawatts, or 7 to 11 new generators by 2030. For fossil with CCS, this assumption limits new plant additions to 2,000 megawatts of demonstration projects or roughly 4 to 8 commercial-sized plants.

EIA cannot attach probabilities to the individual policy cases. However, both theory and common sense suggest that cases that reflect an unbroken chain of either failures or successes in a series of independent factors are inherently less likely than scenarios that do not assume that everything goes either wrong or right. In this respect, the No International/Limited and Zero Bank Cases might be viewed as more pessimistic and optimistic scenarios, respectively, which bracket a set of more likely cases. Similarly, if actual access to international offsets is dependent on a series of independent regulatory and negotiating outcomes, cases with intermediate access to international offsets might be viewed as more likely than those representing either complete and immediate success across the board (High Offsets), or a permanent lack of progress (No International) in such activities.

Results

This section presents the results of the analysis, focusing on the effects of ACESA in the six main cases that vary technology and offset assumptions. The impacts on GHG emissions, energy markets, and the economy are presented in turn. A full set of report tables for all analysis cases is available on the EIA website.

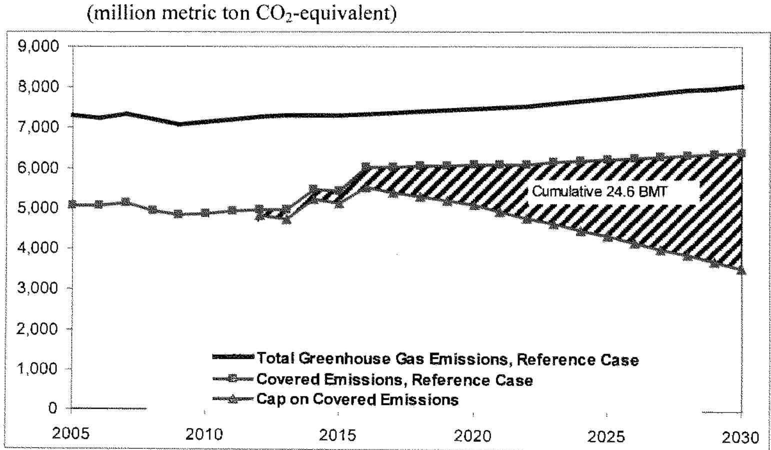
Greenhouse Gas Emissions and Allowance Prices

Greenhouse Gas Emissions and Compliance Patterns

The cap-and-trade provisions in ACESA impose a gradually tightening cap on covered GHG emissions beginning in 2012, with some industrial sector and natural gas coverage phased in between 2012 and 2016. By 2016 about 84 percent of total U.S.GHG emissions are covered emissions under the cap, including most sources of energy-related CO_2 and some industrial emissions of non-energy CO_2, nitrous oxide, perfluorocarbons, sulfur hexafluoride, and HFCs.

Figure 1 compares the total and covered portions of GHG emissions in the reference case under the cap, with covered emissions prior to 2012 shown based on the bill's 2012 coverage provisions.[10] Cumulative covered emissions from 2012 to 2030 in the Reference Case are about 113 BMT, compared to 89 BMT tons allowed under the cap, a 21-percent or 24.6-BMT reduction requirement. Given incentives to bank allowances and an increasingly stringent cap on emissions through 2050, in five of the main analysis cases, an additional 13 BMT of abatement is assumed to occur over the same period, leaving a 13-BMT allowance bank balance at the end of 2030. In the Zero Bank Case, a target of 0 for the 2030 bank balance is assumed.

Figure 1. Reference Case GHG Emissions, Covered Emissions, and Cap, 2005-2030
(million metric ton CO_2-equivalent)



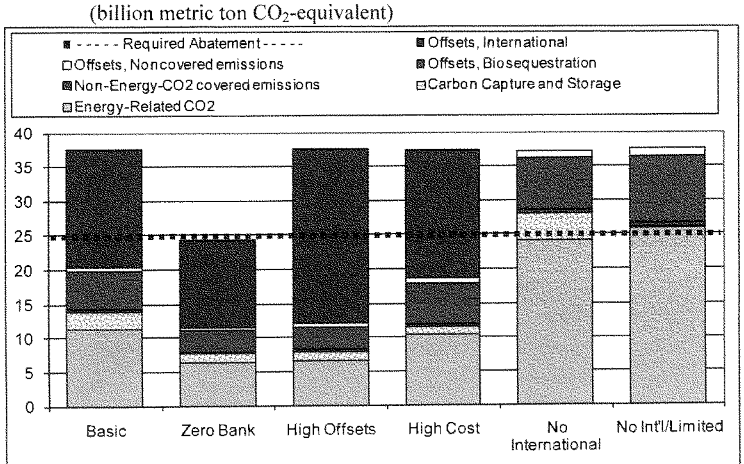
Source: National Energy Modeling System run, STIMULUS.D041409A.

Although all of the main analysis cases start from the same Reference Case, apply the same cap on covered emissions, and five carry the same 13-BMT balance of banked allowances in 2030,

[10] Due to the Energy Information Administration's limited disaggregation of the non-CO_2 gases for modeling purposes, some non-CO_2 gases are modeled as being covered beginning in 2012 rather than 2014. As a result, the percentage of covered gases assumed before 2014 is about 2 percentage points higher than the 66-percent figure cited in ACESA Sec. 721.

the mix of offset usage and reductions in covered emissions vary a great deal across these cases (Figure 2). In the ACESA Basic, ACESA High Cost, and ACESA High Offset Cases, the cumulative use of offsets is projected to substantially exceed the 13-BMT bank balance that is carried forward beyond 2030. Covered entities are therefore able to meet the their obligations under the cap-and-trade program between 2012 and 2030 in those cases even though the reduction in their covered emissions, shown as the bottom three segments of the bars in Figure 2, is significantly below the cumulative 24.6-BMT reduction target shown in Figure 1. This effect is particularly evident in the High Offsets Case, where the reduction in covered emissions over the 2012 to 2030 period is only 8.3 BMT. In the ACESA Zero Bank Case, cumulative abatement matches the minimum required, yet the compliance mix includes a similarly large share of offsets, with international offsets accounting for about half the total abatement. In the two cases where no international offsets are assumed to be available, reductions in covered emissions are much greater, actually exceeding the cumulative 24.6 BMT reduction shown in Figure 1 in the cases that assume the ready availability of low- and no-carbon electric generation technology.

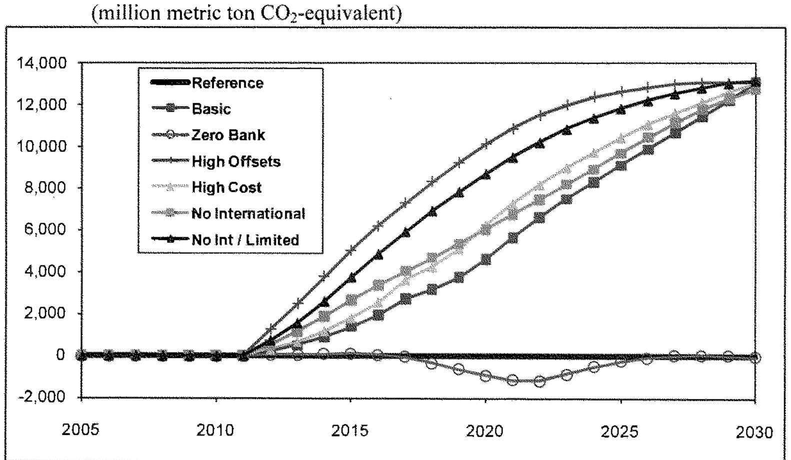
Figure 2. Components of Cumulative Abatement in ACESA Main Cases, 2012-2030
(billion metric ton CO_2-equivalent)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

The temporal pattern of compliance also varies significantly across cases, as shown in Figure 3, which shows the accumulation of allowance bank balances. The build-up of allowance bank balances is most rapid in the High Offsets Case, where the maximum allowable quantity of offsets is assumed to be available immediately. For the other main analysis cases, allowance banks are generally accumulated more rapidly in the cases that assume restricted access to international offsets and/or low- and-no carbon technologies for electricity generation. These assumptions, which lead to higher allowance prices, encourage covered entities to take advantage of near-term fuel-switching opportunities in the electric sector. In the Zero Bank Case, a relatively small negative allowance balance accumulates from 2019 to 2022, reflecting some allowance borrowing as permitted in the bill, subject to some limitations and repayment penalties. The borrowing period is followed by a similar length payoff period, leaving a near-zero balance over the last 5 years of the projection, consistent with the terminal bank assumption of the case.

Figure 3. Cumulative Allowance Bank Balance in ACESA Main Cases, 2012-2030
(million metric ton CO_2-equivalent)

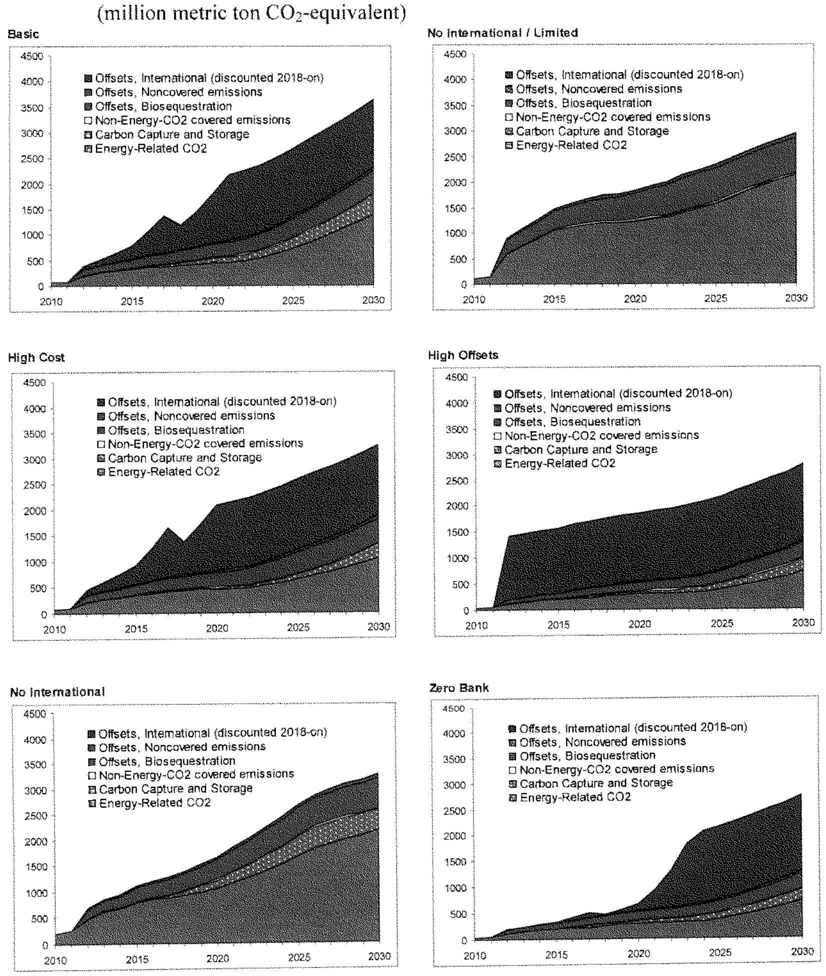


Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Given the relatively generous limit on offsets and their potential as a low-cost compliance option, the reductions in covered emissions are projected to be smaller than the abatement from offsets in most cases. In the ACESA Basic Case, which includes an increasing availability of international offsets over time, abatement in covered gases represents only 39 percent of cumulative total emission abatement from 2012 to 2030. In the ACESA High Offsets Case, where the maximum quantity of international offsets are also used beginning in 2012, abatement in covered gases represents even less of the overall abatement, accounting for just 22 percent of the cumulative abatement through 2030. Reductions in the emissions of energy-related CO_2 account for more than half of the cumulative abatement only in the cases where international offsets are not assumed to be available.

The abatement measures used change over time, depending on how quickly offsets and other abatement opportunities become economical (Figure 4). In the ACESA Basic and ACESA High Cost Cases the "kink" in the international offsets trend occurs due to the discounting rule change that goes into effect in 2018. After 2018, 1.25 international offsets are required for each allowance credit. This discounting is assumed to reduce the market price covered entities in the United States are willing to pay for international offsets to 80 percent (1/1.25) of the domestic

Figure 4. Sources of Cumulative Compliance in ACESA Main Cases, 2010-2030
(million metric ton CO_2-equivalent)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

allowance price and also reduce the quantity of offsets supplied by international sources. Both the discounting and the market supply reaction to the lower international offset price contribute to the reduced use of international offsets in 2018. A second change in the international offsets trend occurs in 2021 when the limit on international offsets is reached.

The temporal abatement pattern in the Zero Bank Case is distinct from the other cases. Relatively low levels of abatement occur in the first 10 years of the cap-and-trade policy in this case, as investors are assumed to forego possible opportunities to bank allowances, as might occur with expectations of stabilizing allowance prices after 2030 that would reduce profits from such investments.

Allowance Prices

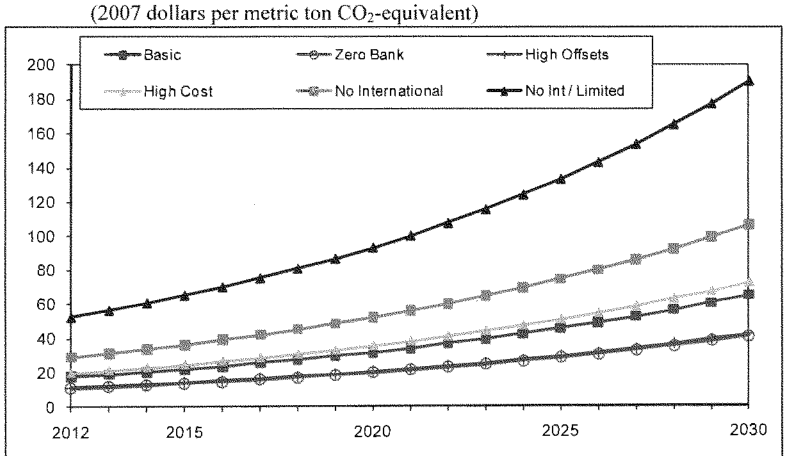
Under the ACESA cap-and-trade provisions, the market price of allowances will establish an incremental cost to emitting GHGs. That cost provides an incentive to reduce emissions whether or not some allowances are received for free, since operating costs can be reduced by emitting less and any unused allowances can be sold.

Prices in allowance markets will be influenced by the banking provisions. Covered entities or traders may hold allowances if they expect higher allowance prices in the future. Allowance prices and levels of emissions are estimated such that covered emissions, less offsets, meet the emissions caps over a time period. The allowance price path is estimated assuming a constant rate of growth matching the cost of capital, or discount rate, assumed in financing the investment in allowance banking. The projected allowance prices represent idealized paths. In reality, allowance prices would tend to fluctuate as markets respond to new information and as unanticipated events unfold.

Allowance prices in the ACESA Basic Case are projected at $32 per metric ton in 2020 and $65 per metric ton in 2030. The projected allowances prices are highly uncertain and sensitive to modeling assumptions, including such factors as the cost and availability of low-emissions technology options and the potential supplies of domestic and international offset credits (Figure 5 and Table 1). Allowance prices in the main cases, where these assumptions are analyzed, vary widely, from $20 to $93 per metric ton of CO_2-equivalent emissions in 2020 and from $41 to $191 per metric ton in 2030. The lower prices in that range occur in cases where technological options such as CCS and adoption of new nuclear power plants become available at relatively low costs, and the use of international offsets helps to hold down compliance costs, as in the ACESA Basic and ACESA High Offset Cases, and where aggregate banking of allowances is minimal, as in the ACESA Zero Bank Case. Significantly higher allowances prices occur if international offsets are unavailable or low-emitting electricity supply technologies are more costly, or the development of these technologies is limited, as in the ACESA No International Offsets, ACESA High Cost, and ACESA No International/Limited Cases.

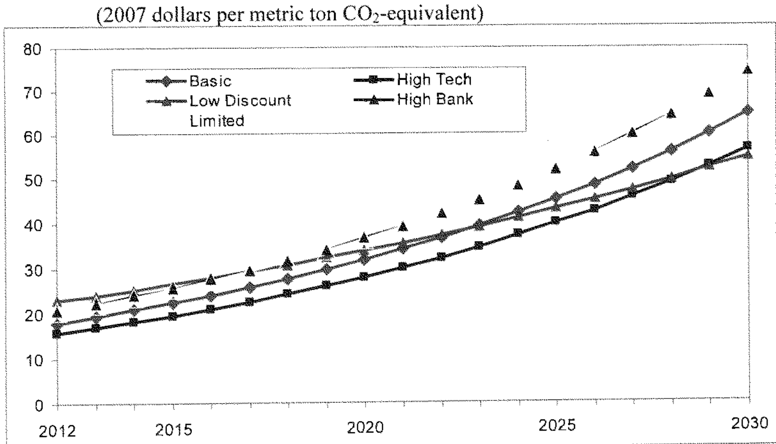
Variation in allowances prices also occurs in some of the additional cases examined (Figure 6 and Table 2). Allowance prices in the ACESA Low Discount Case are initially higher than in the ACESA Basic Case, but they grow at the slower discount rate assumed and end up lower than in the ACESA Basic Case by 2024. Generally, the lower the return that investors in allowances are willing to accept, the greater the incentive to reduce emissions early, building a larger bank of allowances that can be used for compliance later. Relatively high allowance prices result in both the ACESA High Banking and ACESA Limited Alternatives Cases, while relatively lower prices are projected in the ACESA High Tech Case. Not shown are the prices in the ACESA 35CAFE2016 Case, which are not significantly different than in the Basic Case.

Figure 5. Projected Allowance Prices in ACESA Main Cases, 2012-2030
(2007 dollars per metric ton CO_2-equivalent)



Source: National Energy Modeling System runs, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 6. Projected Allowance Prices in ACESA Sensitivity Cases, 2012-2030
(2007 dollars per metric ton CO_2-equivalent)



Source: National Energy Modeling System runs HR2454CAP.D072909A, HR2454DSCT5.D072909A, HR2454HIBNK.D072909A, HR2454BIV.D072909A, and HR2454HITEK.D072909A..

Table 1. Summary Results in ACESA Main Cases

	2007	2020							2030						
			ACESA Cases							ACESA Cases					
		Reference	Basic	Zero Bank	High Offsets	High Cost	No International Offsets	No International / Limited	Reference	Basic	Zero Bank	High Offsets	High Cost	No International Offsets	No International / Limited
Greenhouse gas emissions (mmt)															
Covered emissions															
Energy-related carbon dioxide	4948	5910	5355	5560	5553	5417	4691	4655	6212	4408	5286	5233	4883	3626	4041
Other covered emissions	167	171	150	152	152	149	148	146	177	152	153	154	152	150	146
Total covered emissions	5114	6081	5505	5712	5705	5566	4839	4801	6389	4560	5440	5387	5034	3776	4187
Noncovered emissions	2242	1411	1388	1401	1400	1385	1377	1358	1665	1624	1634	1633	1613	1604	1599
Total greenhouse gas emissions	7357	7492	6893	7113	7105	6951	6216	6158	8054	6184	7074	7020	6647	5380	5786
Offset credits (mmt)															
Noncovered gases	0	0	35	22	23	38	46	65	0	53	43	44	64	73	78
Biogenic sequestration	0	0	251	155	161	278	385	515	0	448	292	301	481	596	676
Total domestic offset credits	0	0	286	177	183	315	431	580	0	501	335	345	545	669	754
International offset credits (post exchange)	0	0	966	135	1305	1272	0	0	0	1320	1479	1470	1361	0	0
Total domestic and international	0	0	1252	312	1488	1587	431	580	0	1821	1814	1814	1906	669	754
Total emissions net of biosequestration and international reductions (mmt)	7357	7492	5435	6789	5313	5084	5831	5643	8054	4086	4932	4882	4465	4784	5109
Cap and trade compliance summary (mmt)															
Allowances issued (cap)	n.a	5086	5086	5086	5086	5086	5086	5086	3554	3554	3554	3554	3554	3554	3554
Covered emissions, less offset credits	5114	6081	4254	5400	4217	3979	4409	4221	6389	2739	3625	3573	3128	3107	3433
Net allowance bank change	0	0	833	-313	870	1107	678	866	0	815	-71	-18	426	447	122
Allowance bank balance	0	0	4616	-930	10122	6221	6033	8720	0	13085	-35	13069	13040	12774	13186
Allowance and offset prices (2007 dollars per metric ton CO2 equivalent)															
Emission allowance	0.0	0.0	31.7	19.9	20.5	35.4	52.1	93.3	0.0	64.8	40.6	41.9	72.2	106.4	190.5
Domestic offset	0.0	0.0	31.7	19.9	20.5	35.4	52.1	93.3	0.0	64.8	40.8	41.9	72.2	106.4	134.0
International offset	0.0	0.0	25.4	15.9	16.4	28.3	41.7	74.6	0.0	22.6	23.3	33.5	22.8	85.1	152.4
Delivered energy prices (including allowance cost after adjustment for free allocations) (2007 dollars per unit indicated)															
Motor gasoline, transport (per gallon)	2.82	3.62	3.82	3.74	3.74	3.84	3.97	4.29	3.82	4.17	4.02	4.03	4.31	4.51	5.10
Jet fuel (per gallon)	2.17	3.02	3.28	3.18	3.18	3.32	3.48	3.85	3.33	3.80	3.58	3.59	3.85	4.18	4.97
Diesel (per gallon)	2.87	3.64	3.90	3.79	3.79	3.92	4.08	4.48	3.88	4.36	4.13	4.15	4.44	4.75	5.61
Natural gas (per thousand cubic feet)															
Residential	13.05	12.91	13.27	13.07	13.10	13.59	13.72	15.91	14.35	16.81	15.49	15.51	18.00	19.06	25.17
Electric power	7.22	7.22	8.52	7.93	8.00	9.08	9.65	13.89	8.57	10.44	9.18	9.20	11.84	12.72	19.49
Coal, electric power sector (per million Btu)	1.78	1.96	4.84	3.76	3.82	5.18	6.60	10.47	2.04	7.82	5.71	5.83	8.64	11.49	19.38
Electricity (cents per kilowatthour)	9.10	9.27	9.51	9.51	9.55	9.65	9.59	10.69	10.05	12.01	11.08	11.12	12.98	12.69	17.83
Energy consumption (quadrillion Btu)															
Liquid fuels	40.8	38.7	37.5	37.7	37.8	37.6	37.3	37.0	40.3	38.3	38.9	38.9	38.4	37.7	37.0
Natural gas	23.7	22.1	21.5	21.6	21.6	22.0	21.5	25.4	24.2	21.1	21.4	21.5	23.0	21.0	26.5
Coal	22.7	24.4	20.6	22.0	21.9	20.2	14.4	10.5	25.4	14.0	20.5	20.2	16.5	6.2	3.9
Nuclear power	8.4	9.1	9.8	9.4	9.4	9.1	10.6	9.1	9.3	16.2	12.0	12.0	9.6	19.4	9.3
Renewable/Other	6.3	10.4	12.2	11.4	11.5	12.5	17.0	15.3	11.8	14.9	14.1	14.2	15.5	18.8	19.3
Total	101.9	104.7	101.6	102.1	102.1	101.3	100.8	97.5	111.0	104.5	106.8	106.7	103.0	103.2	96.0
Purchased electricity	12.8	14.1	13.8	13.8	13.8	13.7	13.7	13.3	15.4	14.5	14.7	14.7	14.2	14.3	13.0
Electricity generation (billion kilowatthours)															
Petroleum	66	49	46	47	46	47	44	45	50	43	46	46	45	41	43
Natural gas	892	714	694	696	704	770	700	1320	976	704	717	721	1040	739	1638
Coal	2021	2198	1875	2003	1987	1833	1309	943	2311	1354	1912	1897	1574	540	300
Nuclear power	806	876	940	904	904	869	1018	876	890	1548	1147	1151	923	1863	890
Renewable/Other	374	738	907	832	837	930	1364	1118	827	1048	1007	1015	1004	1426	1346
Total	4159	4573	4462	4481	4479	4449	4436	4303	5055	4697	4830	4829	4587	4608	4216

mmt: million metric tons of carbon dioxide equivalent

Source: National Energy Modeling System, runs STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A

Note: 2007 total covered emissions reflect the coverage of H.R. 2454 as defined in 2012.

Table 2. Summary Results in ACESA Sensitivity Cases

	2007	2020							2030						
			ACESA Cases							ACESA Cases					
		Reference	Basic	High Tech	Low Discount	35CAFE-2016	High Bank	Limited Alter-natives	Reference	Basic	High Tech	Low Discount	35CAFE-2016	High Bank	Limited Alter-natives
Greenhouse gas emissions (mmt)															
Covered emissions															
Energy-related carbon dioxide	4948	5910	5355	5259	5361	5352	5173	5486	6212	4408	4300	4906	4392	4015	4856
Other covered emissions	167	171	150	151	150	150	150	149	177	152	154	153	153	152	151
Total covered emissions	5114	6081	5505	5410	5511	5502	5323	5635	6389	4560	4454	5059	4545	4167	5007
Noncovered emissions	2242	1411	1388	1392	1386	1388	1384	1384	1665	1624	1627	1628	1624	1611	1611
Total greenhouse gas emissions	7357	7492	6893	6802	6897	6890	6707	7020	8054	6184	6081	6687	6169	5778	6618
Offset credits (mmt)															
Noncovered gases	0	0	35	31	36	34	38	38	0	53	50	49	52	66	66
Biogenic sequestration	0	0	251	220	266	249	285	285	0	448	408	395	446	489	488
Total domestic offset credits	0	0	286	251	303	284	323	323	0	501	458	444	498	555	554
International offset credits (post exchange)	0	0	966	662	1136	945	1251	1295	0	1320	1302	1411	1318	1195	1347
Total domestic and international	0	0	1252	912	1439	1229	1574	1618	0	1821	1760	1855	1816	1750	1902
Total emissions net of biosequestration and international reductions (mmt)	7357	7492	5435	5755	5211	5459	4858	5116	8054	4086	4045	4528	4075	3795	4445
Cap and trade compliance summary (mmt)															
Allowances issued (cap)	n.a	5086	5086	5086	5086	5086	5086	5086	3554	3554	3554	3554	3554	3554	3554
Covered emissions, less offset credits	5114	6081	4254	4498	4072	4273	3748	4017	6389	2739	2694	3204	2728	2417	3105
Net allowance bank change	0	0	833	589	1015	814	1338	1069	0	815	861	350	826	1137	449
Allowance bank balance	0	0	4616	3649	6700	4518	8067	6305	0	13085	12680	12937	13000	19856	13051
Allowance and offset prices (2007 dollars per metric ton CO2 equivalent)															
Emission allowance	0.0	0.0	31.7	27.6	33.8	31.5	36.4	36.3	0.0	64.8	56.8	55.0	64.3	74.3	74.2
Domestic offset	0.0	0.0	31.7	27.6	33.8	31.5	36.4	36.3	0.0	64.8	56.8	55.0	64.3	74.3	74.2
International offset	0.0	0.0	25.4	22.2	27.0	25.2	28.1	28.5	0.0	22.6	22.5	23.0	22.6	22.1	22.7
Delivered energy prices (including allowance cost after adjustment for free allocations) (2007 dollars per unit indicated)															
Motor gasoline, transport (per gallon)	2.82	3.62	3.82	3.77	3.83	3.80	3.85	3.85	3.82	4.17	4.12	4.11	4.15	4.34	4.33
Jet fuel (per gallon)	2.17	3.02	3.28	3.24	3.31	3.26	3.32	3.33	3.33	3.80	3.70	3.70	3.79	3.88	3.87
Diesel (per gallon)	2.87	3.64	3.90	3.84	3.91	3.88	3.93	3.93	3.88	4.36	4.24	4.27	4.36	4.46	4.45
Natural gas (per thousand cubic feet)															
Residential	13.05	12.91	13.27	13.01	13.23	13.21	13.22	13.64	14.35	16.81	16.13	16.26	16.78	17.30	18.66
Electric power	7.22	7.22	8.52	8.08	8.60	8.44	8.58	9.15	8.57	10.44	9.72	9.94	10.40	10.99	12.67
Coal, electric power sector (per million Btu)	1.78	1.96	4.84	4.43	5.03	4.82	5.24	5.29	2.04	7.82	6.96	7.00	7.77	8.58	8.74
Electricity (cents per kilowatthour)	9.10	9.27	9.51	9.15	9.61	9.47	9.42	9.65	10.05	12.01	11.32	11.62	11.97	12.33	13.36
Energy consumption (quadrillion Btu)															
Liquid fuels	40.8	38.7	37.5	37.3	37.8	37.3	37.6	37.6	40.3	38.3	37.9	38.6	38.0	38.1	38.5
Natural gas	23.7	22.1	21.5	21.1	22.0	21.4	21.2	22.0	24.2	21.1	20.3	21.4	21.1	20.8	24.1
Coal	22.7	24.4	20.6	19.8	20.2	20.8	18.9	20.8	25.4	14.0	12.3	18.0	13.9	10.0	12.8
Nuclear power	8.4	9.1	9.8	10.3	9.5	9.8	10.0	9.1	9.3	16.2	17.0	13.0	16.5	18.5	9.3
Renewable/Other	6.3	10.4	12.2	12.2	12.2	12.2	14.4	11.5	11.8	14.9	15.8	14.3	14.7	16.7	17.2
Total	101.9	104.7	101.6	100.8	101.5	101.4	102.1	101.1	111.0	104.5	103.4	105.3	104.3	104.1	101.9
Purchased electricity	12.8	14.1	13.8	13.6	13.7	13.8	13.8	13.7	15.4	14.5	14.1	14.6	14.5	14.4	14.1
Electricity generation (billion kilowatthours)															
Petroleum	66	49	46	48	46	46	45	46	50	43	42	44	43	42	45
Natural gas	892	714	694	645	755	681	646	780	976	704	593	731	699	671	1256
Coal	2021	2198	1875	1802	1837	1893	1726	1906	2311	1354	1154	1712	1341	947	1179
Nuclear power	806	876	940	989	909	937	963	876	890	1548	1634	1249	1582	1775	890
Renewable/Other	374	738	907	932	907	910	1092	836	827	1046	1212	1011	1039	1227	1182
Total	4159	4573	4462	4481	4479	4449	4436	4303	5055	4697	4830	4829	4587	4608	4216

mmt: million metric tons of carbon dioxide equivalent

Source: National Energy Modeling System, runs STIMULUS.D041409A, HR2454CAP.D072909A, HR2454HITEK.D072909A, HR2454DSCT5.D072909A, HR2454CAFE.D072909A, HR2454HIBNK.D072909A, and HR2454BIV.D072909A

Note: 2007 total covered emissions reflect the coverage of H.R. 2454 as defined in 2012.

The lower emissions under the somewhat higher Corporate Average Fuel Economy (CAFE) standards in the early part of the projection occur gradually and do not significantly shift aggregate long-term abatement costs at the margin.

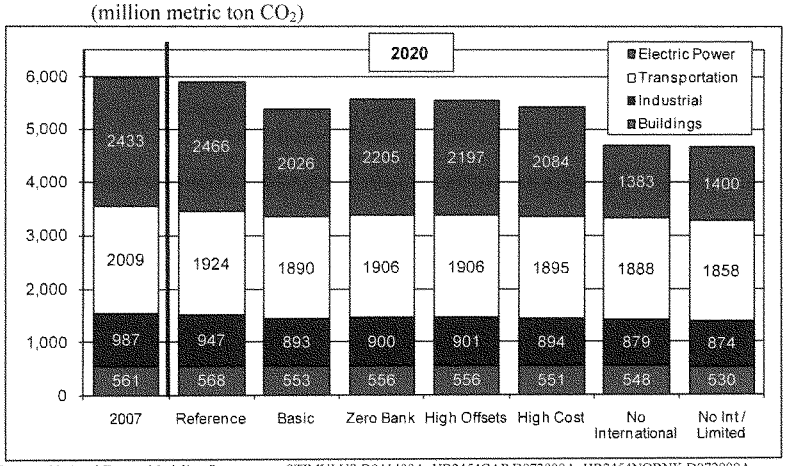
Domestic and international offset prices are closely tied to allowance prices and ACESA's limits on offset usage. Estimated domestic offset usage, which may be constrained by the pro-rata percentage limit imposed on covered emissions, varies across the cases and over time, ranging from 75 to 290 MMT in 2012, from 177 to 580 MMT in 2020, and from 335 to 754 MMT in 2030. In all but one of the main cases examined, the ACESA No International/Limited Case, the estimated quantity of domestic offset credits falls below the pro-rata limits throughout the projection. When offset usage is below the limit, the offset credit price is assumed to match the allowance price. In the No International/Limited Case, the case with the highest allowance prices, the domestic offset limit is reached in 2024 through 2030. Beginning in 2024, competition to supply a limited quantity of offsets drives the offset price below the allowance price.

The limit on international offset credits is initially established to match the domestic limit but is adjusted higher (by up to 500 MMT, or 1,000 MMT less the anticipated domestic offset usage) if domestic offset usage is anticipated to be less than 900 MMT. In the cases where international offsets are assumed to be available, the adjusted international offset limit ranges from 1,196 to 1,479 MMT in 2030, with the estimated limit in the ACESA Basic Case of 1,320 MMT falling in the middle of that range. Given the assumed offset supplies available, international offsets limits are projected to be reached in all of these cases. In the ACESA High Offsets Case, the maximum allowable quantity of international offsets is assumed to be used beginning in 2012, resulting in much lower levels of abatement and allowance prices than in the ACESA Basic Case.

Energy-Related Carbon Dioxide Emissions

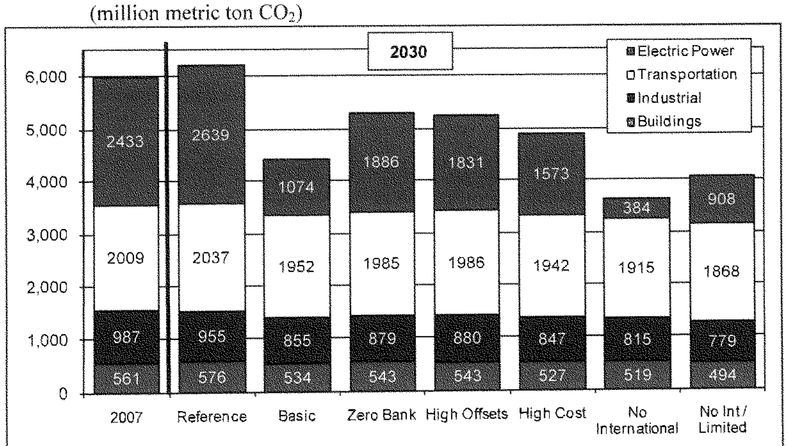
The allowance program and other incentives under ACESA are expected to reduce energy-related CO_2 emissions. The vast majority of the energy-related emissions reductions are expected to occur in the electricity sector (Figures 7 and 8). In fact, across the ACESA main cases, the electricity sector accounts for between 80 percent and 88 percent of the total reduction in energy-related CO_2 emissions relative to the Reference Case in 2030. The electricity sector reductions stem from the use of more efficient, less carbon-intensive sources of generation. This results from a variety of factors, particularly the industry's current dependence on coal, the availability and economics of technologies to switch from coal to less carbon-intensive energy sources, and the comparative economics of fuel switching in other sectors. In addition, a portion of the electricity-related CO_2 emissions reductions results from reduced electricity demand stimulated both by consumers' responses to higher electricity prices and incentives in ACESA to stimulate greater efficiency in energy use.

Figure 7. Energy-Related CO_2 Emissions by Sector in ACESA Main Cases, 2020
(million metric ton CO_2)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 8. Energy-Related CO_2 Emissions by Sector in ACESA Main Cases, 2030
(million metric ton CO_2)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Energy Market Impacts

Energy consumers are expected to face higher costs of using energy as a result of the ACESA cap-and-trade program. To the extent that they are not ameliorated by the free distribution of allowances to regulated distribution companies, the cost of the allowances required to be submitted by covered sources will tend to be passed on to consumers of primary fuels through higher delivered energy prices. Table 1, presented earlier, summarizes the projected impacts on the delivered cost of energy under ACESA. Detailed projection tables on energy production, consumption, and prices for each case accompany the presentation of this report on EIA's web site.[11]

Energy-related emissions will be influenced by both the higher energy costs from the allowance program, as well as the ACESA incentives that promote energy efficiency and low-carbon fuel sources. Overall, the use of fossil fuels generally decreases relative to the Reference Case, while the use of renewable energy sources and nuclear power increases (Figure 9). As discussed earlier, the greatest changes occur in the electricity sector, with reductions in the use of coal and increases in nuclear and renewable fuels in most cases, relative to the Reference Case. The impacts tend to grow over time as the caps become more stringent and the allowance price increases.

Electricity Sector Emissions, Generation, and Prices

The provisions of ACESA alter electric power projections by favoring low-carbon technologies such as new nuclear, renewable, and fossil plants that sequester CO_2. The impact on CCS technology is also affected by the provisions that provide additional incentives for these plants. The shifts in the generation mix caused by ACESA lead to lower CO_2 emissions from the electricity sector, higher electricity prices (particularly after 2025) and lower electricity demand than would otherwise occur. The higher electricity prices are due to the higher capital costs of cleaner, more efficient technologies and the costs of holding allowances.

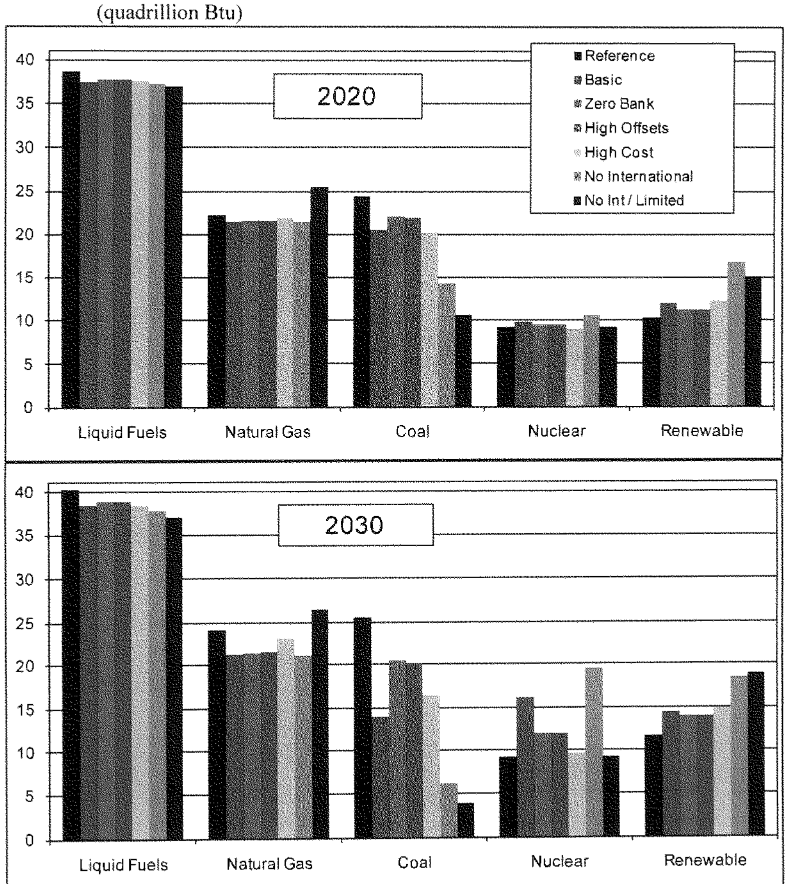
Emissions

In the Reference Case, which assumes no explicit policy to reduce GHG emissions, power sector CO_2 emissions are projected to increase 8 percent between 2007 and 2030 as the industry increases its use of fossil fuels (Figure 10). In the main ACESA cases, power sector CO_2 emissions are expected to be 11 percent to 44 percent below the Reference Case level in 2020 and 29 percent to 85 percent below the Reference Case level in 2030. The electricity sector, in fact, accounts for the vast majority of the energy-related CO_2 emissions reductions expected to occur under ACESA, with its share ranging from 79 to 88 percent in 2030 across the main ACESA cases. The largest changes in electricity emissions occur in the cases where it is assumed that international offsets are not available. Without these offsets, covered U.S. entities must make larger reductions in their own emissions to comply with the emissions cap established in ACESA. In contrast, the smallest change occurs in the ACESA High Offsets Case where

[11] See www.eia.doe.gov/oiaf/service_rpts.htm.

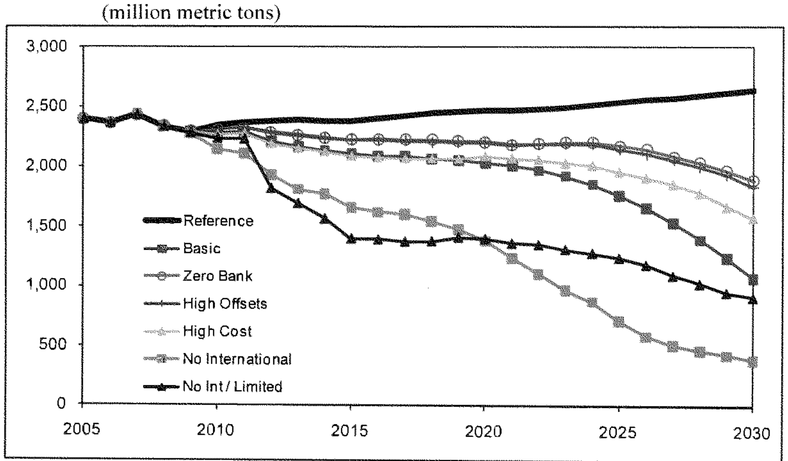
covered entities are assumed to be able to rely more on international offsets as compliance options.

Figure 9. Total Energy Consumption by Source in ACESA Main Cases
(quadrillion Btu)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 10. Electricity Sector CO_2 Emissions in ACESA Main Cases, 2005-2030
(million metric tons)



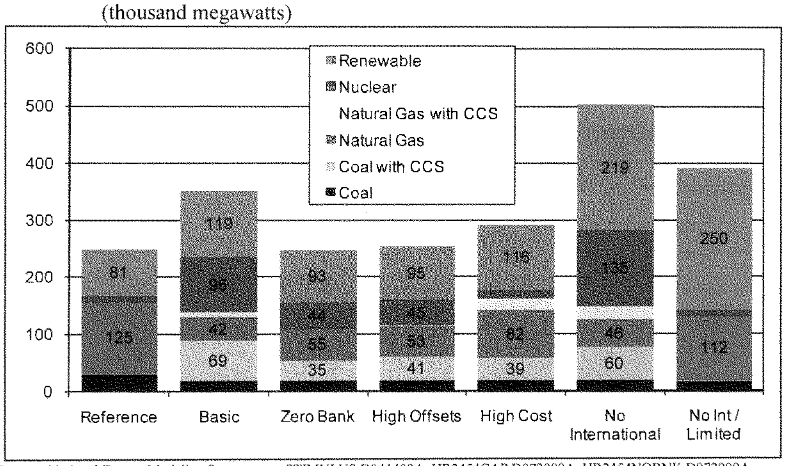
Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Capacity and Generation

In the Reference Case, which does take account of growing concerns about GHG emissions, natural gas plants and renewable plants meet a large share of new capacity requirements through 2030 (Figure 11). Natural-gas-fired generation, with a CO_2 emission rate roughly 40 percent that of conventional coal-fired generation, gains competitiveness relative to coal but loses competitiveness relative to carbon-free technologies under the ACESA cap-and-trade program. The efficiency and cap-and-trade programs in ACESA also have the effect of reducing projected growth in electricity demand, which reduces the need for all generation sources.

Under ACESA, new coal builds without CCS beyond those that are already under construction are almost eliminated. There is also a large increase in coal power plant retirements with between 6 and 85 percent of existing coal capacity projected to retire by 2030 in the ACESA main cases, well above the 1 percent of existing coal capacity projected to retire in the Reference Case. These retiring coal plants are replaced by a combination of new nuclear, renewable, and coal plants with CCS. The Reference Case projects 11 gigawatts of new nuclear capacity by 2030, but under ACESA, nuclear builds by 2030 range from 15 gigawatts to 135 gigawatts, when allowed to grow. Renewable capacity also grows significantly, representing between 33 percent and 63 percent of all new capacity added between 2008 and 2030 across the ACESA main cases.

Figure 11. Cumulative Capacity Additions in ACESA Main Cases, 2007-2030
(thousand megawatts)

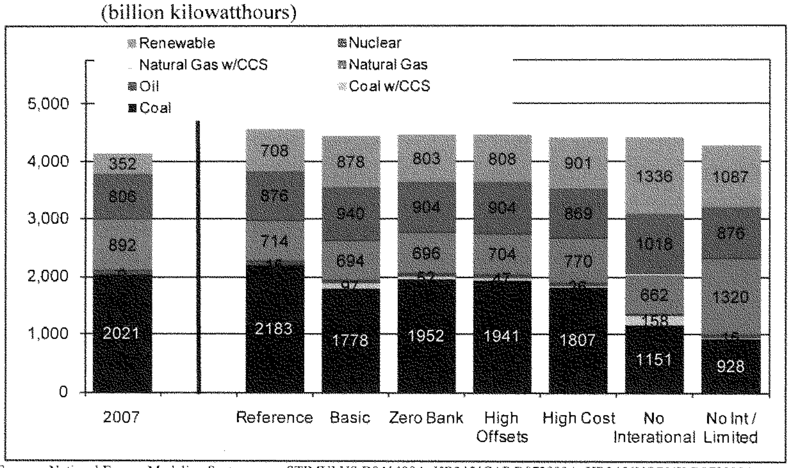


Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

When technologies with CCS, nuclear, and biomass are limited to Reference Case levels, as could occur if the technologies prove more costly, take longer to develop, and/or meet with strong market resistance, the addition of new renewable and natural gas capacity grows significantly. In the ACESA Basic Case, natural gas additions are below those in the Reference Case, since CCS is not as economic on combined-cycle plants as on coal plants, and other non-fossil technologies are built instead of natural-gas-fired plants without CCS.

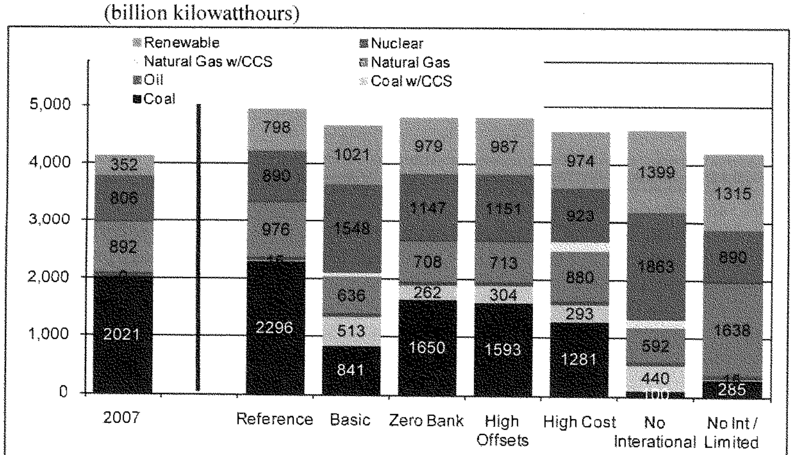
Changes in electricity generation are consistent with capacity choices and are influenced by the GHG allowance price (Figures 12 and 13). In the Reference Case, coal generation grows to 2,311 billion kilowatthours in 2030, an increase of 14 percent over 2007 levels, providing 46 percent of total electricity needs. In the ACESA main cases, coal generation drops, with its generation share in 2030 dropping to between 7 percent and 40 percent. Although some new coal capacity with CCS is added in most cases, the increased generation from these new plants is more than offset by reductions from the retirement of existing coal capacity. In the ACESA High Cost, Zero Bank, and High Offsets Cases, coal generation is above that in the ACESA Basic Case, but still much lower than the Reference Case. In those cases, the higher costs of new coal plants with CCS, the availability of greater international offsets, and/or reduced banking result in fewer coal retirements than in the ACESA Basic Case.

Figure 12. Generation by Fuel in ACESA Main Cases, 2020
(billion kilowatthours)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 13. Generation by Fuel in ACESA Main Cases, 2030
(billion kilowatthours)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

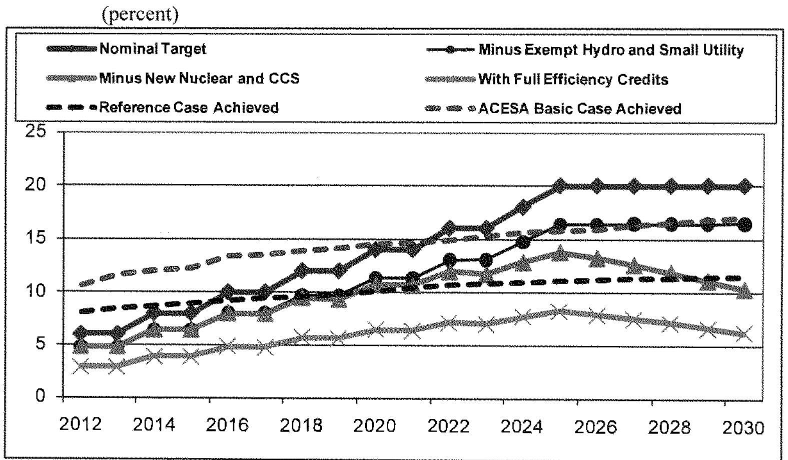
Nuclear generation follows the capacity additions, growing most significantly in the ACESA No International and ACESA Basic Cases. In the Reference Case, nuclear generation grows by 10 percent between 2007 and 2030, reaching 890 billion kilowatthours and providing 18 percent of total generation. In the ACESA Basic Case, nuclear grows to 1,548 billion kilowatthours in 2030, nearly 74 percent more than the Reference Case level. If nuclear costs are higher than expected, then new nuclear capacity additions are still projected but at a level only slightly above that seen in the Reference Case in 2030.

In most of the ACESA cases, natural gas generation in 2030 is lower than in the Reference Case. In the Reference Case, natural gas generation increases 9 percent by 2030, relative to the 2007 level. However, in the ACESA Basic Case, natural gas generation falls 21 percent between 2007 and 2030. In the ACESA No International/Limited Case, natural gas generation is 68 percent above the Reference Case level by 2030, due to the assumed limited availability of new plants with CCS, as well as new nuclear and biomass capacity. This case demonstrates the role of the development and deployment of key low-carbon generating technologies like nuclear, renewables, and fossil with CCS in a timeframe consistent with the emission reduction requirements of ACESA. Without them, allowance prices would be higher and greater demands would be placed on natural gas markets.

Renewable generation is dramatically higher under the provisions of ACESA, growing to between 22 percent and 75 percent above the generation level in the Reference Case in 2030. The vast majority of the increase is from wind generation, followed by biomass generation. The increase in biomass generation in the ACESA cases comes from a combination of increased cofiring of biomass in existing coal plants and the addition of new dedicated biomass plants. In most cases, cofiring dominates, particularly in the early years of the projections. However, as new dedicated biomass plants are added, they play a larger role in the later years. Cofiring is generally an economic way to reduce CO_2 emissions without investing in new capacity, but as the allowance price increases throughout the projections, the economics begin to shift towards less CO_2-intensive generation.

The share of renewable generation far exceeds that required to comply with the combined efficiency and renewable electricity standard in all of the ACESA cases. As shown in Figure 14, the nominal share of renewables required to comply with the target, assuming no efficiency credits, grows to a final target of 20 percent. When the required share is adjusted for the exemption of small utilities and the removal of hydroelectric generation from the baseline, the national average required share falls to approximately 16.5 percent. Moreover, the national average required share falls to just over 10 percent when the generation contribution from new nuclear and fossil plants with CCS is removed from the baseline for renewable electricity standard calculations in the ACESA Basic Case. After these adjustments, the level of renewable generation in the Reference Case exceeds the requirement in 2025 and beyond, while the level in the ACESA Basic Case far exceeds it.

Figure 14. Renewable Electricity Standard Compliance in the ACESA Basic Case, 2012-2030



Source: National Energy Modeling System runs, STIMULUS.D041409A and HR2454CAP.D072909A.

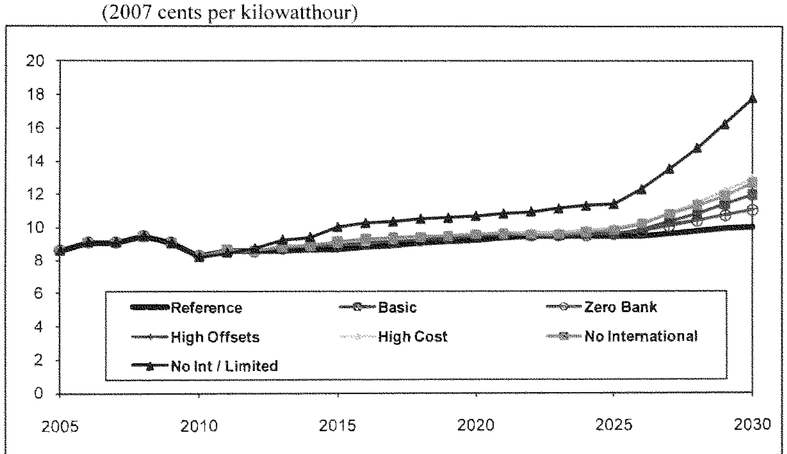
Price and Demand

H.R. 2454 is projected to lead to higher electricity prices and lower electricity demand, though most of the price impacts are expected after 2025, as the allowances allocated to retail electricity providers are phased out. Except for the ACESA No International/Limited Case, electricity prices in five of the six main ACESA cases range from 9.5 to 9.6 cents per kilowatthour in 2020, only 3 to 4 percent above the Reference Case level (Figure 15).[12] Average impacts on electricity prices in 2030 are projected to be substantially greater, reflecting both higher allowance prices and the phase-out of the free allocation of allowances to distributors between 2025 and 2030. By 2030, electricity prices in the ACESA Basic Case are 12.0 cents per kilowatthour, 19 percent above the Reference Case level, with a wider band of 11.1 cents to 17.8 cents (10 to 77 percent above the Reference Case level) across all six main policy cases.

The combination of higher electricity prices and provisions in H.R. 2454 designed to improve energy efficiency causes growth in the demand for electricity to slow relative to the Reference Case in the main ACESA cases. The long-term trend of slowing growth in the demand for electricity is reflected in the Reference Case. After averaging nearly 2.4 percent per year in the 1990s and 1.2 percent per year between 2000 and 2007, the demand for electricity is projected to increase just 0.9 percent per year between 2007 and 2030 in the Reference Case (Figure 16). This projection reflects ongoing improvements in appliance efficiency, new appliance standards, and consumer responses to higher electricity prices. Among the main ACESA cases the growth slows further, ranging from 0.2 percent per year to 0.7 percent per year between 2007 and 2030.

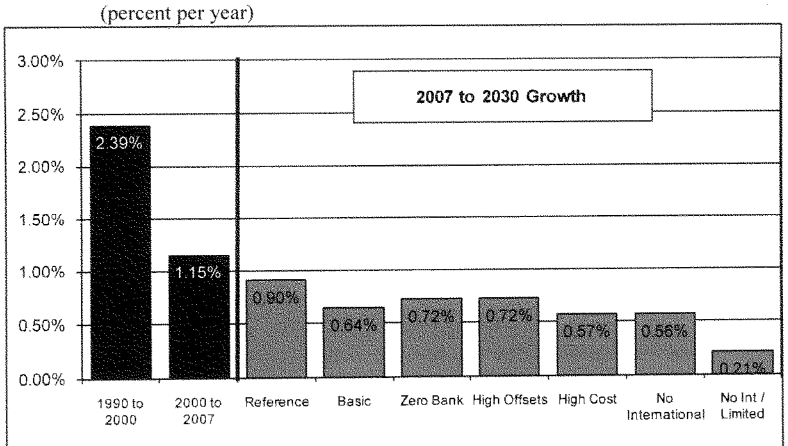
[12] The average electricity price in the No International/Limited case in 2020 is 10.7 cents per kilowatthour.

Figure 15. Electricity Prices in Main ACESA Cases, 2005-2030
(2007 cents per kilowatthour)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 16. Electricity Demand Growth in Main ACESA Cases, 2007-2030
(percent per year)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

The impacts on regional electricity prices vary for many reasons including the demand characteristics, the mix of generating sources used, the availability and delivered prices of different resources and fuels, the regulatory regime, and the local costs of construction (Figure 17). Generally, the largest changes in prices caused by the provisions of H.R. 2454 would be expected in regions that are most reliant on coal, regions without large renewable resources that can be developed, and regions where electricity prices are set competitively. However, since retail distributers remain regulated in all regions it is assumed that the benefit of allowances allocated to them for free will be passed on to their consumers. This significantly dampens the prices impacts of ACESA through 2025 in all regions.

As shown in Figure 17, all regions are expected to see prices increases in most of the ACESA cases by 2030. Regions like the Northwest Power Pool (NWP) and California, which do not rely heavily on coal, continue to have regulated prices, and have significant renewable resources, are projected to see relatively modest prices increases in the ACESA main cases.

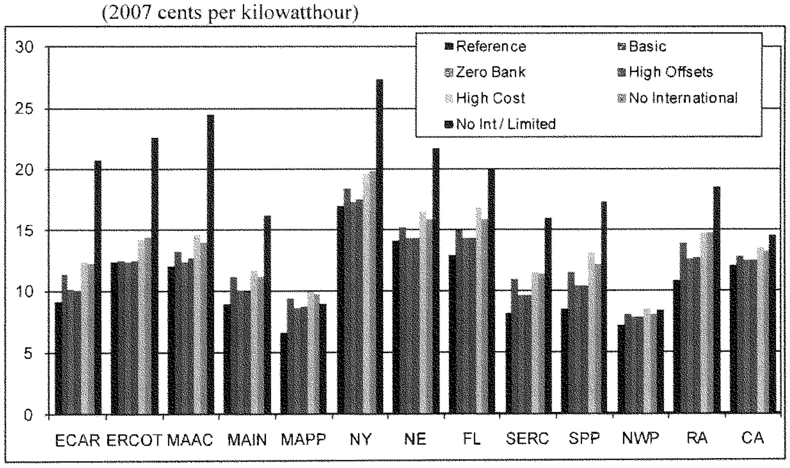
Coal Markets

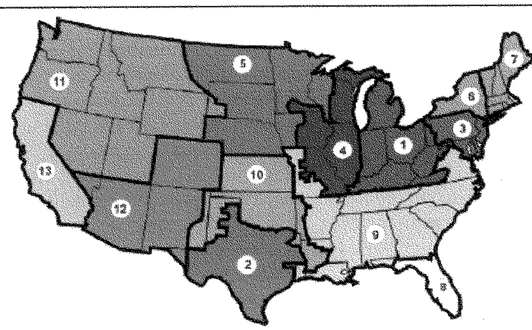
Because coal has the highest carbon content of any of the key fossil fuels, the cost of using coal when a GHG cap-and-trade program is imposed increases dramatically (Figures 18 and 19). For example, in 2020 the cost of using coal in a plant that does not have CCS equipment is between 92 percent and 435 greater in the main ACESA cases than in the Reference Case. By 2030 the increase in coal costs to a plant without CCS equipment is even larger, ranging from 179 percent to 848 percent greater than in the Reference Case in the main ACESA cases. The vast majority of this cost increase is due to the need to hold allowances to cover the CO_2 emissions that will be generated when the coal is used to produce electricity. The underlying delivered price of coal without the allowance costs is actually lower in the ACESA cases because of the reduced consumption of coal.

As a result of the reduced use of coal for electricity generation, coal production volumes (in tons) are projected to be 19 to 83 percent lower in the ACESA main cases in 2030 compared to the Reference Case (Figure 20). Lower coal consumption in the ACESA main cases disproportionately affects western coal producers, because they are expected to meet most of the growth in coal demand in the Reference Case.

Figure 17. Regional Electricity Prices in ACESA Main Cases, 2030

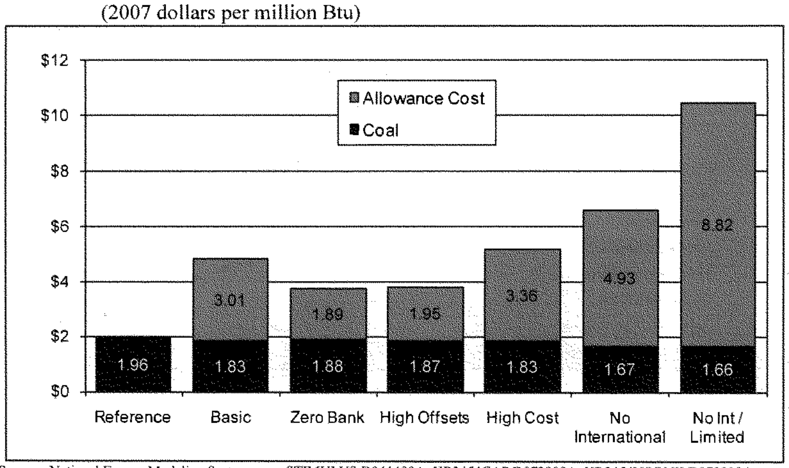
(2007 cents per kilowatthour)





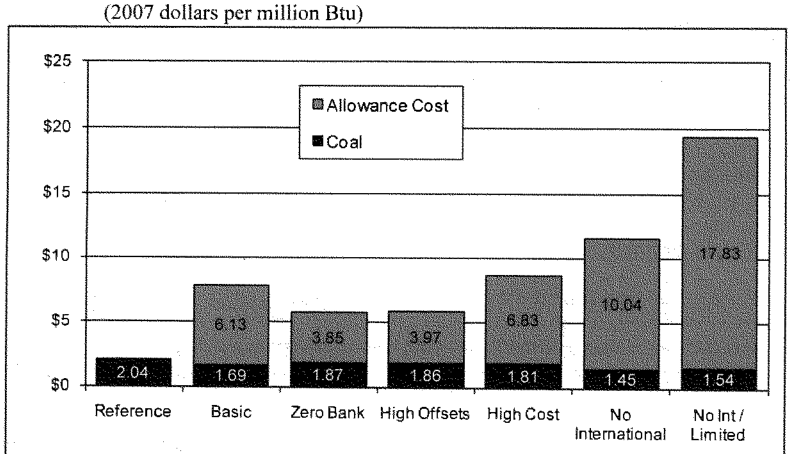
1 East Central Area Reliability Coordination Agreement (ECAR)
2 Electric Reliability Council of Texas (ERCOT)
3 Mid-Atlantic Area Council (MAAC)
4 Mid-America Interconnected Network (MAIN)
5 Mid-Continent Area Power Pool (MAPP)
6. New York (NY)
7. New England (NE)
8. Florida Reliability Coordinating Council (FL)
9. Southeastern Electric Reliability Council (SERC)
10. Southwest Power Pool (SPP)
11. Northwest Power Pool (NWP)
12. Rocky Mountain Power Area, Arizona, New Mexico, and Southern Nevada (RA)
13. California (CA)

Figure 18. Coal Costs to Electricity Producers in ACESA Main Cases, 2020
(2007 dollars per million Btu)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

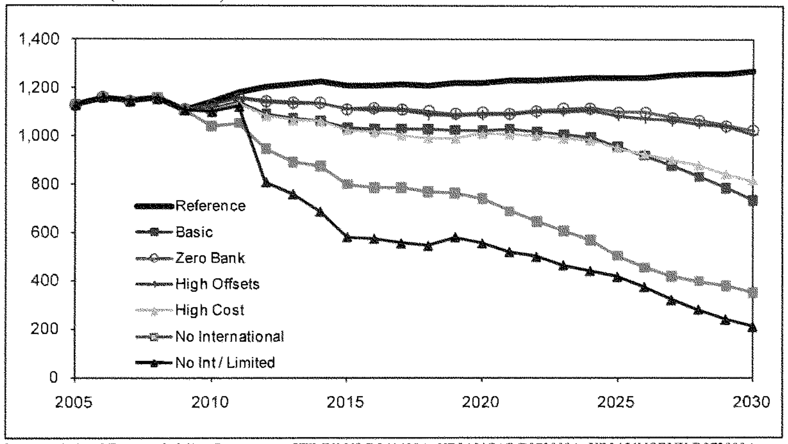
Figure 19. Coal Costs to Electricity Producers in ACESA Main Cases, 2030
(2007 dollars per million Btu)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 20. Coal Production in ACESA Main Cases, 2005-2030

(million tons)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Buildings

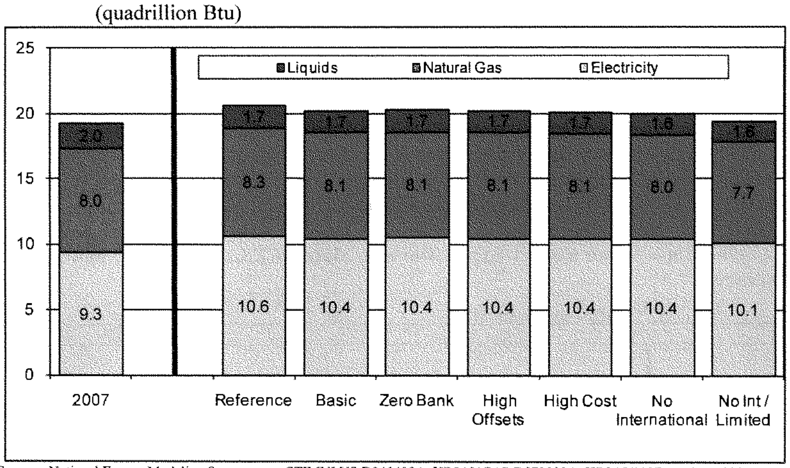
Residential and commercial buildings are affected by programs targeting energy efficiency and the energy price consequences of the GHG emissions cap. Figures 21 and 22 depict buildings sector delivered energy consumption by fuel across the main ACESA cases in 2020 and 2030, respectively. Electricity and natural gas, which account for nearly 90 percent of the delivered energy used in buildings, are also the fuels most impacted by ACESA.

Electricity use in buildings is projected to be 1.5 percent lower in the ACESA Basic Case relative to the Reference Case in 2020, with a range of 1.1 to 4.8 percent across the main ACESA cases. By 2030, electricity use is projected to be 4.9 percent lower in the ACESA Basic Case, with a range of 3.2 to 14.4 percent across the ACESA main cases. In the ACESA Basic Case, most of the electricity savings in buildings is due to price-induced conservation.

Natural gas use in buildings is more directly affected by the energy efficiency provisions in ACESA, given the importance of building codes and building retrofit programs which tend to affect heating fuels more than electricity. In 2020, natural gas use in buildings in the ACESA Basic Case is projected to be 2.5 percent lower than in the Reference Case, with a range of 2.0 to 7.1 percent across the ACESA main cases. By 2030, the ACESA Basic Case is projected to be 7.8 percent lower than the Reference Case with a range of 6.0 to 15.4 percent, across the ACESA main cases. Most of the reduction in natural gas use is due to the energy efficiency provisions in ACESA, particularly the building codes and building retrofit programs.

Figure 21. Buildings Sector Delivered Energy Consumption by Fuel in Main ACESA Cases, 2020

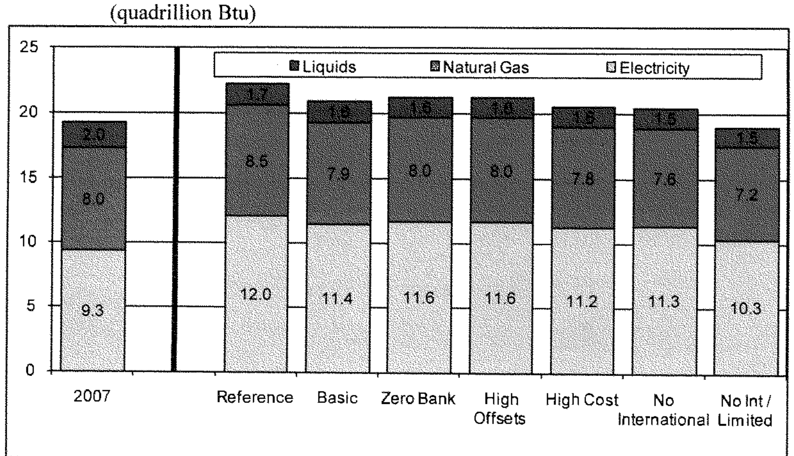
(quadrillion Btu)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 22. Buildings Sector Delivered Energy Consumption by Fuel in Main ACESA Cases, 2030

(quadrillion Btu)

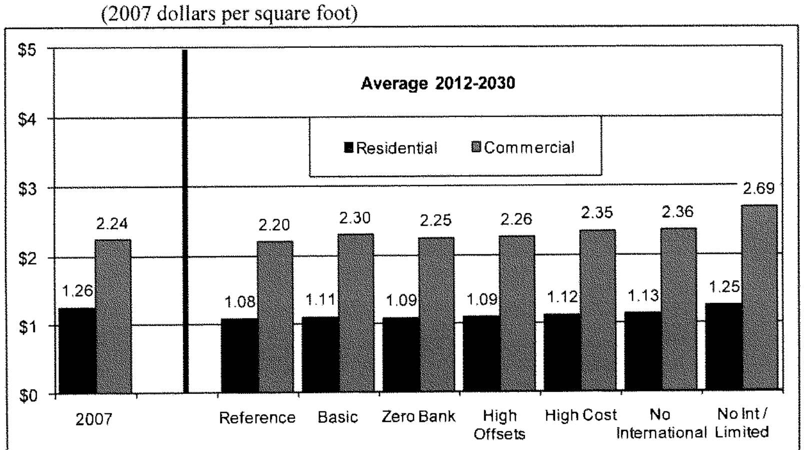


Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Even with lower energy consumption in the main ACESA cases, energy expenditures are projected to increase, relative to the Reference Case, due to increases in delivered energy prices to the buildings sector. Figure 23 depicts the average projected energy expenditures per square foot in residential and commercial buildings over the 2012 through 2030 period in the main ACESA cases. These estimates include **only** expenditures for energy used in buildings and not any additional costs associated with the purchase of energy-efficient equipment or any transportation costs. For all residential and commercial buildings, energy expenditures in the ACESA Basic Case are projected to increase 4 percent over the Reference Case average over the 2012–to-2030 period on a per–square-foot basis (in real 2007 dollars). Of all the main ACESA cases, only the most restrictive case shows an increase in the average expenditures per square foot relative to 2007, when energy expenditures were at near-record highs in real terms.

Figure 23. Buildings Sector Energy Expenditures in Main ACESA Cases, 2007 and 2012-2030 Average

(2007 dollars per square foot)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Increases in energy prices impact households not only for the energy used in the house, but also for transportation costs and products they buy on an everyday basis. Several provisions in ACESA direct that the funds generated from emissions allowance auctions or the sale of freely allocated allowances be used to ameliorate the adverse impact on households. In addition to the funds generated for low-income households through the auctioning of 15 percent of the allowances allocated each year, local electricity and natural gas distribution companies are also directed to use freely allocated allowances to minimize the impact on residential energy consumers. These provisions, along with the energy efficiency programs such as building codes, partially shield residential consumers from significant increases in energy expenditures for uses inside the house. Transportation costs, however, do increase significantly on a per-household basis since there are no provisions designed to dampen motor gasoline price impacts.

As a result of the provisions in ACESA, the average household can expect increases in the cost of the energy they use to heat and cool their homes as well as the cost to operate their vehicles. Figures 24 and 25 depict these cost increases as well as the increase in the cost to purchase more energy-efficient equipment as a result of more stringent building codes. Since the building codes affect only new construction on an annual basis and the annualized cost (over 15 years) is spread out over all households in Figures 24 and 25, the impact of the increase in this cost is relatively small. Based on the three cost measures represented in Figure 24, households can expect an increase of $165 in 2020 in the ACESA Basic Case, with a range of $103 to $767 across the ACESA main cases. Increases in light-duty vehicle energy expenditures account for about 81 percent of the increase in 2020 in the ACESA Basic Case. In 2030, the cost to the consumers increases to $501 per household in the ACESA Basic Case, with the non-transportation costs accounting for about 52 percent of the increase (Figure 25). In 2030, the increased costs to households range from $282 to $1,870 across the ACESA main cases. The higher cost impacts in 2030 are stimulated by the rising allowances costs and the phase-out of the freely allocated allowances to electricity and natural gas distribution companies that begins in 2025.

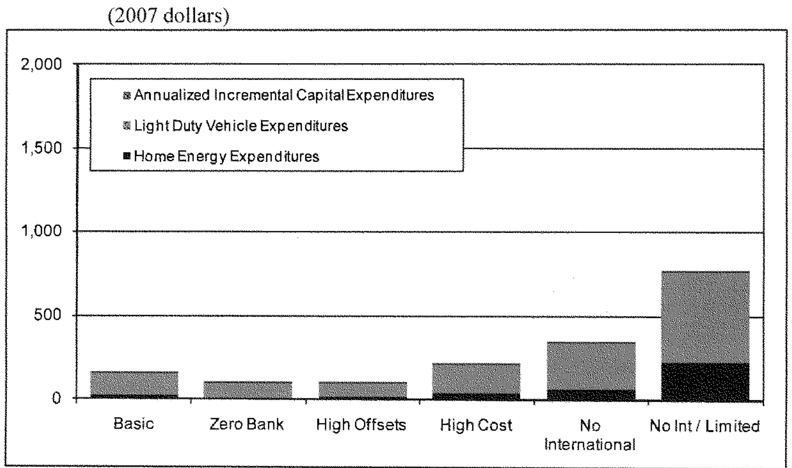
The adoption of more efficient technology can play a role in mitigating the cost to households due to ACESA. In the ACESA High Tech Case, energy expenditures for household uses (excluding transportation costs) decline by $63, relative to the Reference Case, in 2020. In 2030, energy expenditures for household uses increase by $26 relative to the Reference Case, but are much less than the $191-increase projected in the Basic Case. The increased adoption of more efficient technologies, including rooftop photovoltaics, contributes to the reduction in household energy expenditures. Total per-household expenditures are lower in this case, relative to any of the main cases, even with a modest increase in annualized capital expenditures caused by the adoption of more efficient equipment. Per-household expenditures are 54 percent lower in 2020 relative to the Basic Case and 40 percent lower than the Basic Case in 2030.

Transportation

The impact of ACESA on projections of CO_2 emissions from the transportation sector are relatively small compared to emissions reductions realized in the other demand sectors. In 2020, CO_2 emissions from the transportation sector are reduced from1.0 percent to 3.5 percent (19 to 68 MMT) across the main ACESA cases relative to the Reference Case. By 2030, transportation-related CO_2 emission reductions increase and range from 2.6 percent to 8.5 percent (53 to 174 MMT) across the main ACESA cases compared to the Reference Case.

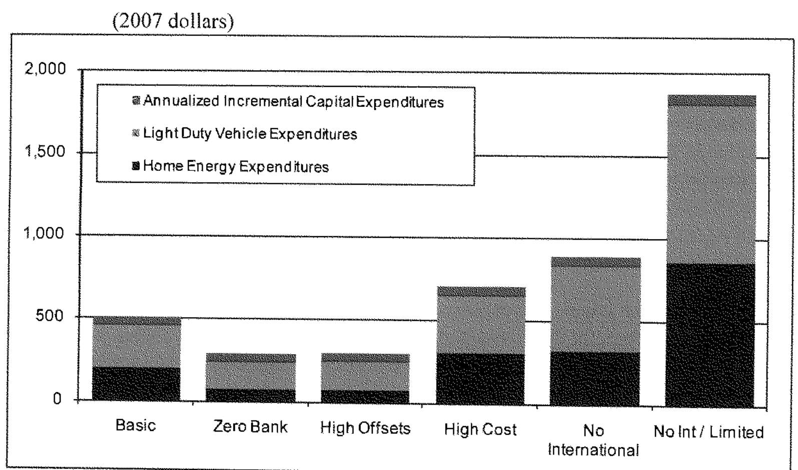
Because reductions in transportation-related emissions are not proportional to reductions in other sectors, by 2030 the transportation sector accounts for a larger percentage of total U.S. GHG emissions across all cases. The relatively small changes in the transportation sector are driven by the modest changes in gasoline prices, which are expected by 2020 to range from $0.12 to $0.66 per gallon higher than in the Reference Case (Figure 26).

Figure 24. Average Change in Household Energy Expenditures in Main ACESA Cases, 2020



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

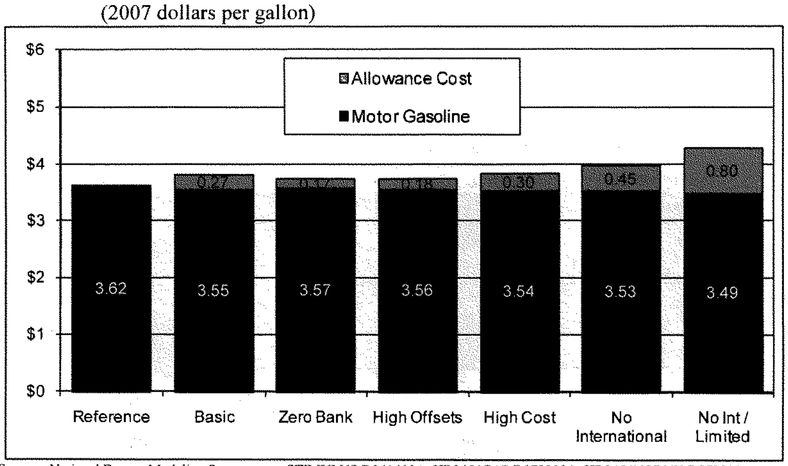
Figure 25. Average Change in Household Energy Expenditures in Main ACESA Cases, 2030



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 26. Motor Gasoline Prices in Main ACESA Cases, 2020

(2007 dollars per gallon)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

However, ACESA does contain provisions aimed at stimulating further advances in vehicle fuel efficiency and a more rapid penetration of vehicles that rely at least partially on electricity. Uncertainty about the impacts of these provisions led to them not being explicitly analyzed in this report. If they are successful, larger reductions in transportation sector emissions would be expected.

These results may also be impacted by proposed revisions to CAFE standards. On May 19, 2009, President Obama unveiled new light vehicle fuel economy standards increasing the minimum passenger car requirement to 39 miles per gallon and the light truck requirement to 30 miles per gallon by model year 2016. The proposed rule making jointly developed by the EPA and the National Highway Traffic Safety Administration mandates a 5-percent annual increase in fuel economy for model years 2012 through 2016. The new standards will address both fuel economy and GHG emissions via a vehicle-attribute-based CAFE standard and a tailpipe GHG emission standard.

To evaluate their potential impact, the proposed CAFE standards were incorporated into the 35CAFE2016 Case. Except for the revised CAFE standards, this case uses the same assumptions as the ACESA Basic Case, to examine the impact on transportation-related GHG emissions and how that effects total GHG emission reductions from all sectors. Relative to the ACESA Basic Case, the proposed CAFE standards reduce GHG emissions from the transportation sector by 0.5 percent in 2020 (9 MMT carbon-equivalent) and 0.8 percent in 2030 (16 MMT carbon-equivalent) relative to the ACESA Basic Case. Total GHG emissions are unchanged between the two cases since reductions in the transportation sector are offset by smaller reductions in other sectors. This occurs because allowance prices decrease in proportion to emissions reductions achieved in the transportation sector.

The transportation sector could contribute more to emissions reductions if the provisions of ACESA were to spur more rapid improvement in transportation technology. Relative to the ACESA Basic Case, in the ACESA High Tech Case, transportation sector CO_2 emissions are 32 million metric tons lower in 2030 (1.6 percent).

Economic Impacts

Implementing the ACESA GHG cap-and-trade program will affect the economy through two key mechanisms. First, the cost of using energy, particularly fossil fuels and electricity, will be increased by the requirement to submit allowances for ongoing emissions. Second, the auctioning of allowances and the free distribution of allowances to emitting and non-emitting sources will generate revenue, which, in turn, will be spent by various government entities on programs designed to help businesses and consumers reduce their emissions or ameliorate the impacts associated with higher energy prices. In the ACESA cases, roughly 99 percent of the value of allowances, allocated freely or auctioned, goes to producers and consumers of energy from 2012 to 2030, while 1 percent is devoted to deficit reduction. Through 2025, the allocation of allowances under ACESA tends to dampen the changes in energy prices, but energy prices begin to escalate and the economy shows greater losses in the last 5 years of the projection horizon, as many of the early programs are phased out..

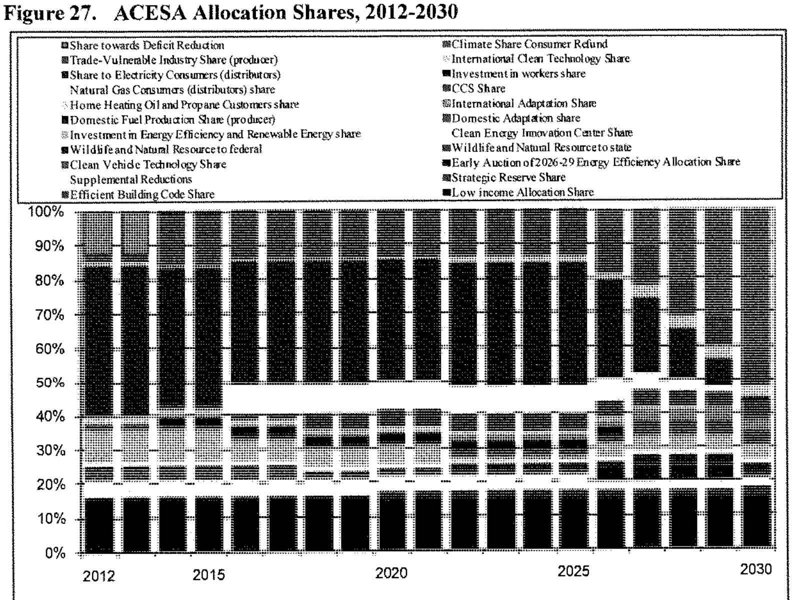
Prices increase and real output declines as a result of meeting the carbon reductions stipulated in ACESA. If all of the revenue collected by the carbon allowances were returned, deficits would be significantly higher, especially during the period where the carbon allowance prices are at their highest levels. As a result, for all ACESA cases, the full employment deficit was not allowed to change from the reference case. Government expenditures were adjusted so that the deficit remained at reference case values. The uses of the carbon allowance revenues as stipulated by H.R. 2454 were modeled; however to the extent that the resulting change in government expenditures were lower than the actual amounts specified by the bill, other non-defense government expenditures would have to be reduced to insure unchanged Federal deficits over time.

Allowance Revenues

Figure 27 shows the detailed shares of allowances going to different entities as called for in ACESA over the 2012 to 2030 time period. As shown, the share devoted to the energy industry, mainly to be used to reduce impacts on their consumers, drops off dramatically post-2025, with an increasing share rebated to consumers via the climate change consumer refund program. The amounts going to the energy industry and trade-vulnerable industries are not directly collected as revenue in the macroeconomic model. Those revenues are used by the industries themselves to lessen the impact of rising energy prices to consumers. The remaining uses of the allowances are distributed through Federal transfer payments abroad (International Adaptation and Clean

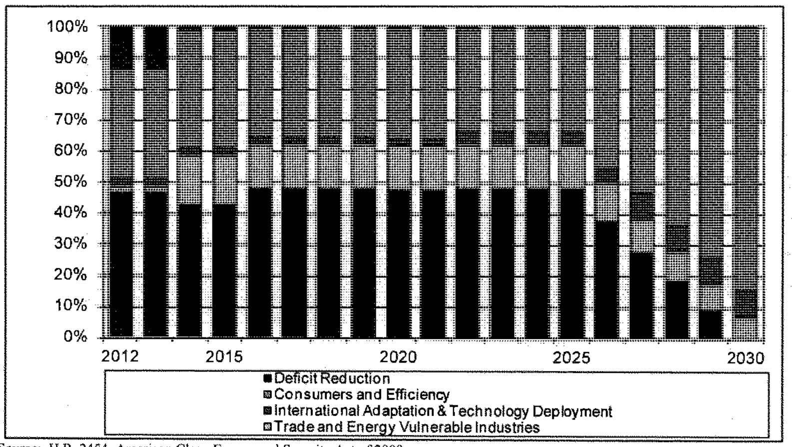
Technology Deployment funds), imports of services (purchases of international offsets), increased transfer payments to individuals (low income allocations), or increased Federal non-defense expenditures (clean energy innovation centers and energy efficient programs). The cumulative amount of revenues (not discounted) collected for redistribution by the government ranges from $1.3 trillion in the ACESA Zero Bank Case to $6.4 trillion in the ACESA No International/Limited Case between 2012 and 2030. These sums essentially include the value of all the allowances that will fund increased local, State, and Federal government expenditures for various purposes but exclude the value of allowances going directly to businesses, including to local electricity and natural gas distribution companies, or those that will be used for deficit reduction. Figure 28 provides another view of the distribution of allowances dividing them into five broad categories, electricity, natural gas and oil distributors, trade- and energy-vulnerable industries, international adaptation, consumers and efficiency, and deficit reduction.

Figure 27. ACESA Allocation Shares, 2012-2030



Source: ACESA H.R. 2454 Sections 726, 781 and 782.

Figure 28. ACESA H.R. 2454 Allocation of Revenue by Major Category, 2012-2030



Source: H.R. 2454, American Clean Energy and Security Act of 2009.

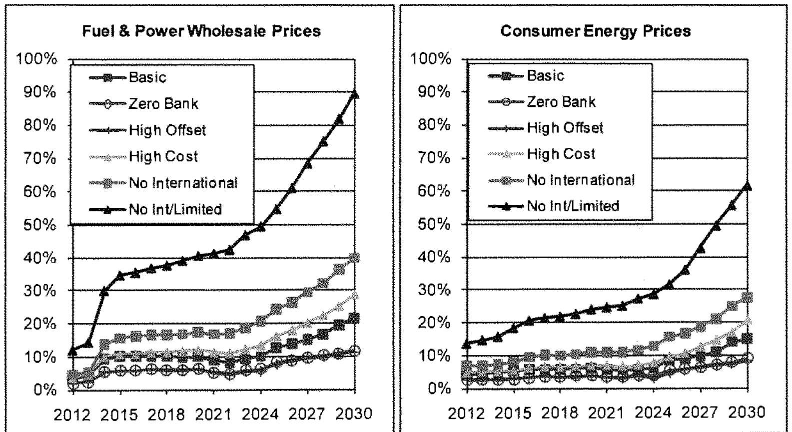
Impacts on Energy and Aggregate Prices

Rising energy costs influence the aggregate economy through their effect on prices and energy expenditures. Figure 29 shows the percentage changes in both the consumer and producer indices for energy in the ACESA cases. Figure 30 highlights the All-Urban Consumer Price Index (CPI), a measure of aggregate consumer prices in the economy. The CPI for energy, a summary measure of energy prices facing households at the retail level, increases by approximately 15 percent above the Reference Case level by 2030 in the ACESA Basic Case. Industrial energy prices increase by 22 percent above the Reference Case by 2030. However, between 2012 and 2025, when electricity, natural gas, and heating oil distributors are assumed to use the large amount of allowances they receive to mitigate the impacts that their customers would otherwise see, industrial energy prices rise by roughly twice as much in percentage terms as do consumer energy prices.

Both wholesale and consumer energy prices rise quickly in the first 4 years, level off for the next 10 years and then sharply rise for the last 5 years. All cases show the same pattern with the amount of increase depending on the allowance prices and compliance options chosen in each case. The relative stability of energy prices from 2014 to 2025 reduces projected economic impacts from levels experienced following the initial energy price shock. However, when energy prices start to escalate post-2025, economic impacts begin to grow.

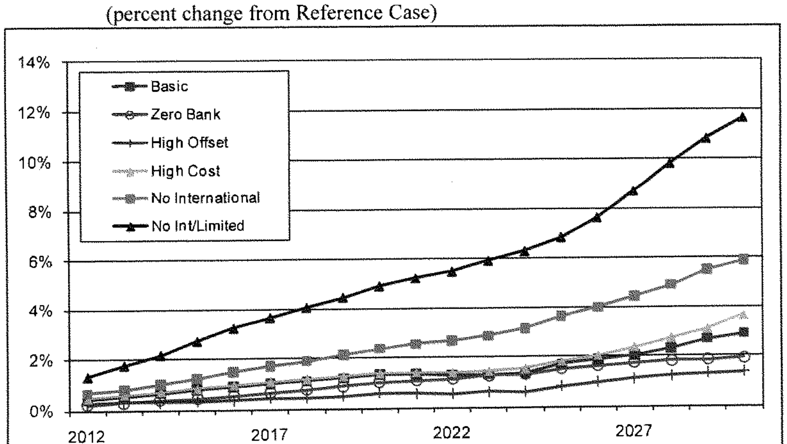
Across the ACESA cases, consumer energy prices increase between 8 and 62 percent above the Reference Case level in 2030, with the ACESA High Offsets Case showing the smallest change in energy prices and the ACESA No International/Limited Case showing the largest change, more than twice that in the next highest case.

Figure 29. Wholesale and Consumer Energy Prices in ACESA Main Cases, 2012-2030



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 30. Change in Consumer Prices in ACESA Main Cases, 2012-2030
(percent change from Reference Case)



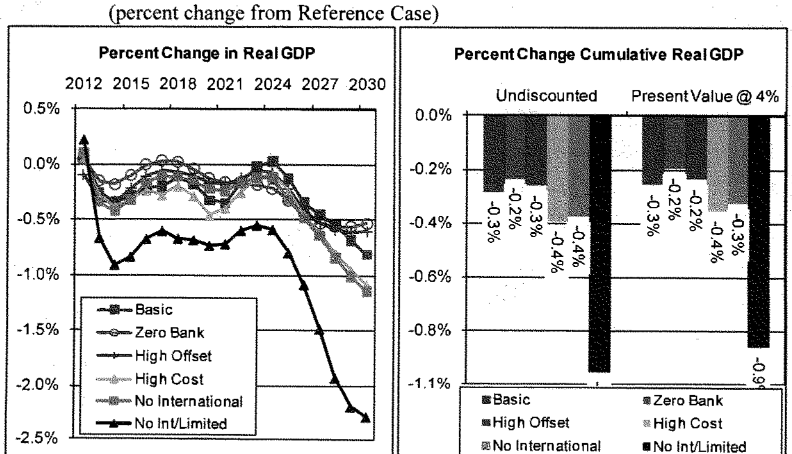
Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Ultimately, consumers will also see the impact of higher energy prices directly through final prices paid for energy-related goods and services and higher prices for other goods and services using energy as an input, and, if the cost increases cannot be passed on to consumers, labor and capital stock may be reallocated. Figure 30 shows that the increase in consumer prices ranges from 1.5 percent to 12.0 percent above Reference Case levels in the main ACESA cases, with the increase in the No International/Limited Case nearly twice that in the next highest case.

Real GDP and Consumption Impacts

The higher delivered energy prices lead to lower real output for the economy. They reduce energy consumption, but also indirectly reduce real consumer spending for other goods and services due to lower purchasing power. The lower aggregate demand for goods and services results in lower real GDP relative to the Reference Case (Figure 31 and Table 3). Over the entire projection period, the change in the cumulative present value of GDP from the Reference Case in the ACESA Basic Case is 0.3 percent ($566 billion in 2000 dollars), with a range from $432 billion (-0.2 percent) to $1,897 billion (-0.9 percent) across the main ACESA cases. Impacts in the No International/Limited Case are more than twice as high as those in any other case.

Figure 31. Change in Real GDP in ACESA Main Cases, 2012-2030
(percent change from Reference Case)



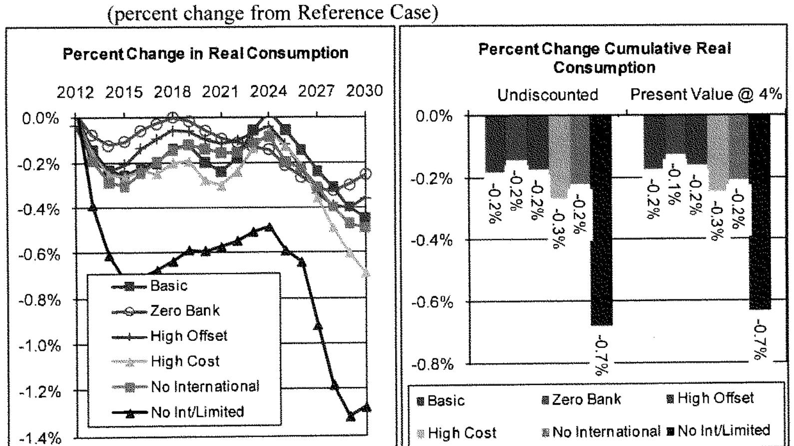
Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Over time, the pattern of GDP impacts mirrors the change in energy and allowance prices. GDP losses are fairly small for the first 10 years as energy prices increase initially and then stabilize. Real GDP impacts actually decline as prices stabilize, but then increase again as energy prices start to escalate after 2025 as allowance prices continue to rise and the allocation of allowances used to mitigate the impacts on electricity, natural gas, and heating oil consumers is phased out. In 2030, the last year explicitly modeled in this analysis, GDP losses range from $104 billion to $453 billion (-0.5 to -2.3 percent), with the losses in the ACESA No International/Limited Case, at the top of these ranges, again more than twice as large as those in the case with the next highest level of impacts.

While real GDP is an overall measure of what the economy produces, the components of GDP, consumption, investment, government, and net exports, may change considerably. In the ACESA cases, consumer expenditures, one indicator of consumers' welfare, show smaller relative losses than overall GDP. Figure 32 shows consumption impacts over time and the cumulative discounted percent change in consumption over the 2012 to 2030 time period relative to the Reference Case. The cumulative percent losses for real consumption range from 0.1 percent ($196 in billion 2000 dollars) in the ACESA Zero Bank Case to 0.7 percent ($988 in billion 2000 dollars) in the No International/Limited Case. As with GDP, consumption losses during the first 10 years of the projection period are relatively small because consumer energy prices increase by half of the change in industrial energy prices and remain relatively steady until 2026 and roughly 15 percent of total nominal allowance revenue is returned to low-income consumers. In fact, until 2026, the value of increased residential energy expenditures (including transportation costs) is roughly equal to the amount of allowance revenue transferred to low-income consumers. After 2026, the consumer climate change funds rebates in personal taxes, allowing for muted consumer impacts of the rising energy costs.

By 2030, real consumption losses reach 0.4 percent ($63 billion in 2000 dollars) in the ACESA Basic Case.

Figure 32. Change in Real Consumption in ACESA Main Cases, 2012-2030
(percent change from Reference Case)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Table 3. Macroeconomic Impacts of ACESA Main Cases Relative to the Reference Case
(billion 2000 dollars, except where noted)

	Basic	Zero Bank	High Offsets	High Cost	No International	No Int / Limited
Cumulative Real Impacts 2012-2030 (present value using 4-percent discount rate)						
GDP						
Change	-566	-432	-523	-781	-717	-1897
Percent Change	-0.3%	-0.2%	-0.2%	-0.4%	-0.3%	-0.9%
Consumption						
Change	-273	-196	-252	-384	-323	-988
Percent Change	-0.2%	-0.1%	-0.2%	-0.3%	-0.2%	-0.7%
Industrial Shipments (excludes services)						
Change	-910	-753	-480	-958	-1720	-2877
Percent Change	-1.0%	-0.8%	-0.5%	-1.1%	-1.9%	-3.2%
Nominal Revenue Collected 2012-2030[a]	2971	1292	1332	2299	3462	6350
2020 Impacts (not discounted)						
GDP						
Change	-50	-19	-26	-70	-34	-112
Percent Change	-0.3%	-0.1%	-0.2%	-0.5%	-0.2%	-0.7%
Consumption						
Change	-21	-7	-11	-30	-15	-64
Percent Change	-0.2%	-0.1%	-0.1%	-0.3%	-0.1%	-0.6%
Industrial Shipments (excludes services)						
Change	-68	-54	-32	-69	-108	-186
Percent Change	-1.0%	-0.8%	-0.5%	-1.0%	-1.6%	-2.8%
Nominal Revenue Collected[a]	71	44	46	79	118	215
2030 Impacts (not discounted)						
GDP						
Change	-161	-104	-120	-214	-226	-453
Percent Change	-0.8%	-0.5%	-0.6%	-1.1%	-1.1%	-2.3%
Consumption						
Change	-63	-36	-50	-97	-69	-180
Percent Change	-0.4%	-0.3%	-0.4%	-0.7%	-0.5%	-1.3%
Industrial Shipments (excludes services)						
Change	-183	-125	-87	-198	-338	-506
Percent Change	-2.5%	-1.7%	-1.2%	-2.7%	-4.6%	-6.8%
Nominal Revenue Collected[a]	330	205	211	367	556	1030

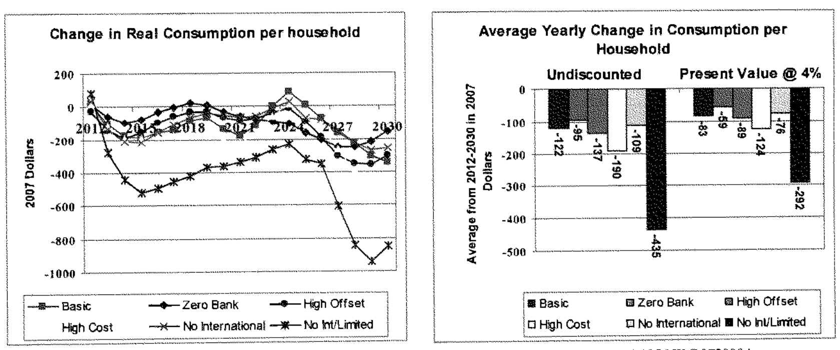
[a] Includes revenues from allowance auctions and revenues generated by the resale of allowances distributed to non-emitters. These values are not discounted.
Note: All changes shown are relative to the Updated *AEO2009* Reference Case.
Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

On a per-household basis, average non-discounted consumption losses ranges from $95 to $435 (in 2007 dollars) over the 2012 to 2030 period in the ACESA cases. When discounted, the yearly losses average from $59 to $292 (in 2007 dollars) per household. The consumption losses escalate starting in 2025 as the allowance prices increase to meet the more stringent emission cap. Therefore 2020 household consumption costs are smaller than the losses in 2030 (Figure 33). The household consumption losses grow over time as energy prices escalate. The 2030 consumption losses per household are larger than the losses in 2020 as both the carbon allowance price and electricity prices increase rapidly post-2025 (Figure 34). In 2020, household consumption losses range from $30 to $362; while in 2030, the range in consumption losses is from $157 to $850 per household.

Industrial Impacts

Industrial energy prices increase more than consumer energy prices because of the allowance revenue used to ameliorate energy price impacts for consumers. On average, wholesale energy prices increase by double that of consumer energy prices. Figure 35 indicates that industry[13] shows larger percentage losses than consumption. By 2030, industrial shipment losses range from 1.2 percent in the High Offset Case to 6.8 percent in the No International/Limited Case. Manufacturing industries show slightly larger percentage losses than the total industrial sector.

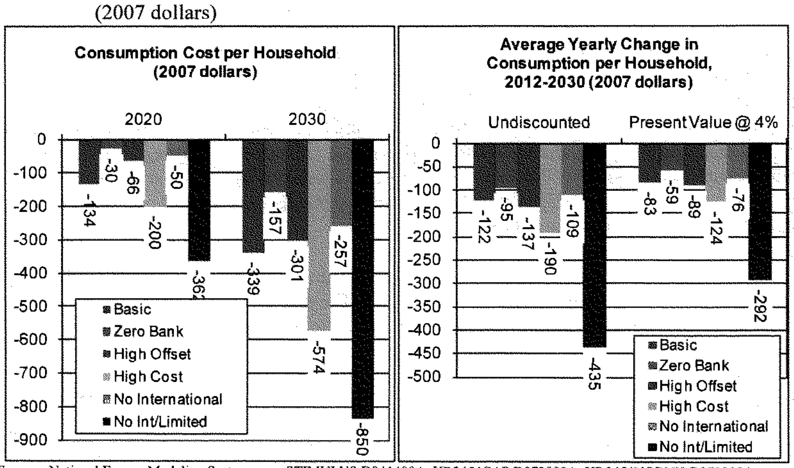
Figure 33. Household Consumption Cost in ACESA Main Cases
(2007 dollars)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

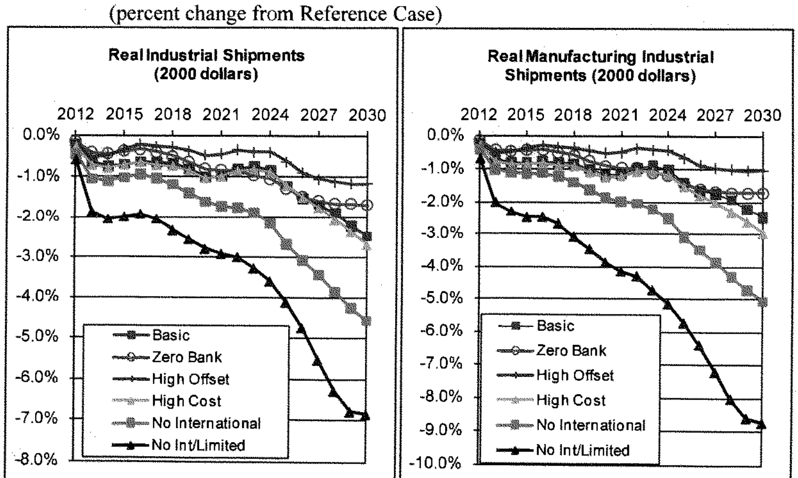
[13] In this section, industry is defined as non-service output. Industry includes manufacturing, agriculture, construction, and mining, which are the industries used by the NEMS industrial demand module.

Figure 34. Change in Household Consumption in ACESA Main Cases, 2020 and 2030
(2007 dollars)



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

Figure 35. Industrial Impacts in ACESA Main Cases, 2012-2030
(percent change from Reference Case)

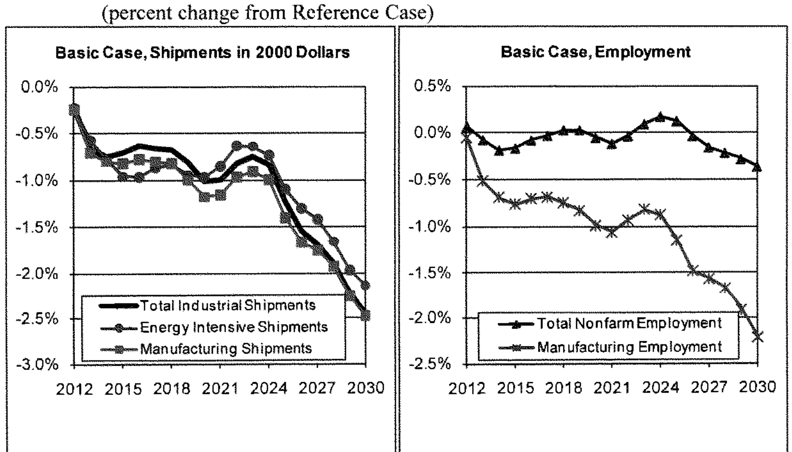


Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

As allowance prices increase, the energy-intensive sectors, including bulk chemicals, glass, cement, steel, and aluminum, receive permit allocations of roughly 15 percent of the total allocated in 2013. Their allocation share gradually declines over time, such that by 2030 trade- and energy-vulnerable industries obtain just under 7 percent of the allocated permits. Receiving these permits ameliorates the impact of increased energy prices and therefore industries face energy prices that are not impacted by the permit values.[14] As a result, when energy prices increase, the reductions in output of these trade- and energy-vulnerable industries are less than overall manufacturing impacts and mirror the impacts (in terms of percentage change from the Reference Case) of total industrial shipments. In past EIA analysis of industrial impacts of energy price increases, these energy-intensive industries typically experience larger losses compared to overall manufacturing (Figure 36).

Total non-farm employment percentage losses are smaller than manufacturing primarily because gains in employment in the service sectors (Figure 36). The pattern of manufacturing employment losses over time mirrors the pattern shown by real manufacturing shipments in all cases.

Figure 36. Industrial and Employment Impacts in the ACESA Basic Case, 2012-2030
(percent change from Reference Case)



Source: National Energy Modeling System runs, STIMULUS.D041409A and HR2454CAP.D072909A.

The main ACESA cases give a wide range of industrial impacts depending on which technology (and its costs) the electricity sector uses and the availability of international offsets. One additional source of uncertainty in the macroeconomic model is how exchange rates will react to the imposition of a carbon allowance price. Given no information on how other countries would implement carbon emission caps and that the macroeconomic model used in NEMS focuses on primarily domestic economic impacts, the exchange rates were not allowed to change from

[14] See Appendix B for detailed methodology of incorporating these industrial output-based rebates.

Reference Case levels. See Appendix B for a description of the assumptions used in the macroeconomic model for the ACESA cases.

Comparison to Earlier EIA Analysis

EIA has analyzed a number of cap-and-trade bills and policies in recent years. In 2008 EIA evaluated S. 2191, the Lieberman-Warner Climate Security Act of 2007, which was introduced in the 110th Congress.[15] S. 2191 included an economy-wide cap-and-trade provision covering about 87 percent of GHG emissions, with those emissions capped at 40 percent below the 2005 level in 2030 and 72 percent below the 2005 level in 2050. The caps in ACESA are more stringent than those under S. 2191, requiring reductions of 58 percent reduction from 2005 levels in 2030 and 83 percent in 2050 and beyond; however, ACESA allows greater use of offsets as a compliance measure compared to S. 2191.

For S. 2191, EIA estimated allowance prices in 2030 of between \$62 to \$160, including \$62 in the Core Case and \$80 in the High Cost Case (prices in 2007 dollars per metric ton CO_2-equivalent). This compares to EIA's range of \$41 to \$191 for ACESA, including \$65 in the ACESA Basic Case which is most similar to the S. 2191 High Cost Case in terms of electricity cost assumptions. EIA's S. 2191 analysis was based on the *Annual Energy Outlook 2008* (*AEO2008*) that included different energy price paths and macroeconomic growth assumptions from *AEO2009*, among other differences. In the *AEO2009*, long-run economic growth is slightly lower at 2.4 percent between 2008 and 2030, compared to *AEO2008*'s projected growth at 2.5 percent. Short-run growth is substantially lower in the *AEO2009* relative to *AEO2008* as a result of the current recession. Compliance costs as reflected in the estimated allowance prices would tend to be lower under the *AEO2009* Reference Case than under the *AEO2008* Reference Case,[16] suggesting somewhat closer compliance costs between ACESA and S. 2191, at least as reflected in allowance prices.

The ACESA allowance allocations and rebates help compensate energy consumers and energy-intensive businesses for higher energy costs and play a key role in the estimated energy market and macroeconomic response, relative to the projected allowance prices. For energy-intensive industries, output and employment impacts are less than under S. 2191 since, under ACESA, energy-intensive industries are assumed to be compensated for higher energy costs due to allowance prices. Under S. 2191, energy-intensive industries were assumed to face the full cost of allowance in higher energy prices.

Similarly, consumer and wholesale energy price increases are mitigated under ACESA through 2025 as rebates from local distribution companies offset the effect of rising allowance prices on electricity and natural gas prices. After 2025, these energy prices grow more rapidly as rebates

[15] Energy Information Administration, *Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007*, SR/OIAF(2008-01) (Washington, DC, April 2008), web site www.eia.doe.gov/oiaf/servicerpt/s2191/index.html.

[16] For the published *AEO2009*, EIA included as a side case an updated S. 2191 Case, called the "LW110" Case, with assumptions similar to the S. 2191 High Cost Case from the 2008 Service Report. The estimated 2030 allowance price in the *AEO2009* LW110 was \$74 per metric ton, compared to \$80 allowance price in the original S. 2191 High Cost Case based on *AEO2008*.

are phased out, a different pattern than under S. 2191. Under ACESA, energy prices increase immediately in 2012 and then stabilize until 2025, allowing the economy to recover from the initial price increase. After 2025, the rapid increase in energy prices causes the economy to contract.

This effect of rebates on energy prices under ACESA accounts for the different time paths of GDP and consumption losses in the two studies. Under S. 2191, the losses are immediate and increase gradually over time. Under ACESA, real GDP and consumption losses are relatively small until 2025, but escalate rapidly late in the projection period. As a result, the cumulative macroeconomic impacts estimated under S. 2191, relative to the estimated allowance prices, were greater than those observed under ACESA, even though the 2030 impacts are less. For example, in the S. 2191 Core Case, with a 2030 allowance price of $62, the average undiscounted loss in real consumption from 2012 to 2030 was estimated to be $47 billion (2000 dollars). In the ACESA Basic Case, with a 2030 allowance price of $65, the average undiscounted loss in real consumption from 2012 to 2030 was $22 billion. The pattern of carbon allowance recycling in S. 2191 and H.R. 2454 differed. Revenue recycling to consumers did not have a sudden increase post-2025 in S. 2191 as it does in H.R. 2454. In H.R. 2454, since the consumer climate change fund is rebated to the consumer in the form of lower personal taxes post-2025, consumption impacts in S. 2191 and H.R. 2454 are similar, $68 billion for S. 2191 and $63 billion for H.R. 2454 in 2030.

Appendix A: Analysis Request Letter

ONE HUNDRED ELEVENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115

MAJORITY (202) 225–2927
FACSIMILE (202) 225–2525
MINORITY (202) 225–3641

energycommerce.house.gov

March 17, 2009

Mr. Howard K. Gruenspecht
Acting Administrator
Energy Information Administration
1000 Independence Avenue, SW
Washington, DC 20585

Dear Mr. Gruenspecht:

One of the top priorities of the Committee on Energy and Commerce is to pass comprehensive climate change legislation. To facilitate this effort, we are requesting technical assistance from the Energy Information Administration (EIA). In particular, we request that EIA estimate the economic impacts of our draft legislation as it is developed. EIA's analysis of the draft legislation would prove useful to us and other members of the House as we craft measures to combat global climate change.

We ask that EIA begin this process by meeting with our staff to discuss the parameters, methods, and duration of the analysis. Please call Alexandra Teitz, Lorie Schmidt or Joel Beauvais at (202) 225-4407.

Sincerely,

Henry A. Waxman
Chairman

Edward J. Markey
Chairman
Subcommittee on Energy and Environment

Appendix B: Representing H.R. 2454 in the National Energy Modeling System

Emissions Modeling

The analysis of energy sector and economic impacts of the various greenhouse gas (GHG) emission reduction measures in the American Clean Energy and Security Act of 2009 (ACESA) is based on the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) which is used for projections in the *Annual Energy Outlook 2009* (*AEO2009*), including an updated Reference Case that reflects provisions of the American Recovery and Reinvestment Act (ARRA) and recent changes in the economic outlook.[17] The updated *AEO2009* Reference Case is used as the baseline for the analysis in this report.

The projection horizon for NEMS extends to 2030, while the emissions policies in the bill extend to 2050 and beyond. As a result, this analysis is limited to addressing the bill's impacts through 2030; however, some expectations of post-2030 changes affect the modeling, such as assumed allowance banking behavior through 2030 and an assumed continuance of allowance price trends beyond 2030 when simulating electric power capacity decisions through 2030.

NEMS endogenously calculates changes in energy-related carbon dioxide (CO_2) emissions in the analysis cases. The cost of using each fossil fuel includes the costs associated with the GHG allowances needed to cover the emissions produced when they are used. These adjustments influence energy demand and energy-related CO_2 emissions. The GHG allowance price also determines the reductions from projected baseline emissions of other covered GHGs based on assumed abatement cost relationships, as well as the potential supplies of domestic and international offsets. With emission allowance banking, NEMS solves for a starting allowance price and trend such that cumulative emissions match the cumulative emissions target, including cumulative bank allowances, with a constant-growth trend in allowance prices consistent with the average cost of capital to the electric power sector.

The NEMS Macroeconomic Activity Module (MAM), which is based on the IHS Global Insight U.S. Model, interacts with the energy supply, demand, and conversion modules of NEMS to solve for an energy and economy-wide equilibrium. In an iterative process within NEMS, MAM reacts to changes in energy prices, energy consumption, and allowance revenues, solving for the effect on macroeconomic and industry level variables such as real gross domestic product (GDP), the unemployment rate, inflation, and real industrial output.

Title III Cap–and-Trade Provisions

Title III of ACESA modifies the Clean Air Act by adding Titles VII and VIII to limit emissions of most GHGs through an allowance cap-and-trade system (Title VII) and to impose and modify emissions standards affecting other GHGs (Title VIII). Title III of ACESA also establishes various financial regulations on allowance markets. EIA's modeling of Title III provisions was limited to the allowance cap-and-trade system. EIA's analysis does not reflect a separate cap-and-trade system on certain hydrofluorocarbons (HFCs) used primarily as substitutes for ozone-

[17] Energy Information Administration, *Annual Energy Outlook 2009*, DOE/EIA-0383(2009)(Washington, DC, February 2009), web site www.eia.doe.gov/oiaf/aeo/index.html, and *An Updated AEO2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, DOE/EIA-SR-OIAF/2009-03 (Washington, DC, April 2009).

depleting substances. Nor does it address the emission standards on other GHG sources not covered by the cap-and-trade system, such as methane emissions for landfills and coal mines.

Establishing the Cap and Coverage Assumptions

Sec. 721 establishes the overall cap on GHGs by specifying the number of allowances to be created each year under certain assumptions about overall 2005 emissions and the coverage fractions in 2012, 2014, and 2016 as additional coverage is phased in. The yearly allowance quantities are based on specific percentage reductions in 2012, 2020, 2030, and 2050 relative to the applicable emissions from covered sources in 2005. The bill sets the reductions targets at 3 percent in 2012, 17 percent in 2020, 42 percent in 2030, and 83 percent in 2050. See Table B1.

Table B1. Revisions to the GHG Cap for Emissions Accounting and Limitations in Modeling Detail

(million metric tons CO_2-equivalent)

	Assumed in Bill		As Modeled	
	Emission Level	Percentage of Total	Emission Level	Percentage of Total
2005 Total Emissions	7206	100.0	7303	100.0
2005 Covered emissions, 2012 coverage	4770	66.2	4975	68.1
2005 Covered emissions, 2014 coverage	5455	75.7	5589	76.5
2005 Covered emissions, 2016 coverage	6089	84.5	6128	83.9
Year	**Specified Cap**	**Percentage of 2005 Covered Emissions**	**Revised Cap as Modeled**	**Percentage of 2005 Covered Emissions**
2012	**4627**	**97.0**	**4826**	**97.0**
2013	4544	95.3	4739	95.3
2014	5099	93.5	5225	93.5
2015	5003	91.7	5128	91.8
2016	5482	90.0	5515	90.0
2017	5375	88.3	5408	88.3
2018	5269	86.5	5301	86.5
2019	5162	84.8	5194	84.8
2020	**5056**	**83.0**	**5086**	**83.0**
2021	4903	80.5	4933	80.5
2022	4751	78.0	4780	78.0
2023	4599	75.5	4627	75.5
2024	4446	73.0	4474	73.0
2025	4294	70.5	4320	70.5
2026	4142	68.0	4167	68.0
2027	3990	65.5	4014	65.5
2028	3837	63.0	3861	63.0
2029	3685	60.5	3708	60.5
2030	**3533**	**58.0**	**3554**	**58.0**
2050	**1035**	**17.0**	**1042**	**17.0**

The bill establishes a procedure for revising the cap based on any changes in the emissions accounting affecting the relative emissions by covered entities or the total 2005 emissions. Accordingly, EIA has revised the assumed cap slightly to conform to EIA GHG accounting practices and the level of emissions accounting incorporated into NEMS, while adhering to the percentage targets for 2012, 2020, and 2030 set forth in the bill. Targets for intervening years are established by using a uniform annual decline in the amount of emissions between the years specified. Table B1 presents the original and revised caps as assumed in this analysis through 2030.

The bill phases in the allowance requirements for some emission sources. Emissions from petroleum combustion and electric power companies are covered at the onset of the program starting in 2012. In 2014 and 2015, it is estimated that approximately 72 percent of the natural gas used in the industrial sector is subject to the allowance holding requirement. The allowance obligation for local distribution companies (LDCs) supplying natural gas to non-covered entities begins in 2016. It was assumed that CO_2 emissions from natural gas that is not consumed by covered industrial and electric power companies will be supplied by LDCs. Therefore all CO_2 emissions from natural gas are assumed to be covered beginning in 2016. By 2016, all energy-related CO_2 emissions, other than those attributed to a small amount of residential and commercial sector coal usage, are assumed to be covered.

A small amount of emissions from other industrial emissions are also subject to the allowance holding requirement. These gases include nitrous oxide from adipic acid and nitric acid production, non-energy process emissions of carbon dioxide, and emissions of fluorinated gases other than those HFCs used as substitutes for ozone-depleting substances (a separate cap on the latter group of gases is established in the bill but is not treated in the modeling conducted for this report). Due to model limitations, the coverage of emissions of these gases is programmed to begin in 2012, rather than in 2014 as required in the bill.

Limits on Offset Credits

H.R. 2454 establishes an overall limit on international and domestic offset credits of 2 billion metric tons (BMT) of the allowance requirements, with each source limited to half the total. The domestic and international offset limits are applied on a pro-rata basis on individual covered entities. The pro-rata limit is a maximum percentage of the allowance obligation that can be met using offsets. The pro-rata limit can therefore restrict offset usage independently of the overall 2-BMT limit. The pro-rata limit is calculated as follows:

$MaxOffSetPct_y = 100 * (2000 / (2000 + CAP_y))$, where

$MaxOffSetPct_y$ is the maximum percentage of the allowance obligation that can be met through offsets in year y, and

CAP_y is the emissions cap, or number of allowances issued, for year y, in million metric tons CO_2-equivalent.

The pro-rata limit would restrict the aggregate use of offsets below the overall 2-BMT limit unless covered emissions exceeded the cap by 2 BMT, assuming all covered entities used the maximum allowable percentage. As with the overall limit, domestic and international offsets under the pro-rata limit can each be no more than half the total, with one exception which can be triggered by the Environmental Protection Agency (EPA) Administrator. If the EPA Administrator expects the availability of domestic offset credits to be less than 900 million metric tons (MMT) in any year given expected allowance prices, the maximum percentage of international offsets is increased, and the domestic offset percentage decreased. The maximum offset percentage is changed to reflect an increase in the international offsets by an amount equal to 1,000 MMT less the expected domestic offset availability, up to an increase of 500 MMT of additional international offsets.

Domestic offset credits substitute for allowances on a 1-for-1 basis. International offset credits are exchanged for allowance requirements on a 1-for-1 basis through 2017. Beginning in 2018, 1.25 international offset credits are required to substitute for one allowance.

Assumptions for Non-CO_2 Emissions Abatement and Offset Supplies

Assessing ACESA requires an analysis of energy-related CO_2 emissions and non-CO_2 GHG emissions. NEMS represents U.S. energy markets and the associated CO_2 emissions and abatement opportunities endogenously. Non-CO_2 GHG emissions and international offsets are represented using exogenous baseline emissions projections and schedules of abatement opportunities over time and by price. To reflect the reduction in non-energy-related GHG emissions, EIA relies on these assumed economic relationships to quantify the potential emissions abatement and offset supplies that would occur over a range of allowance or offset prices.

To a great extent, EIA bases abatement and offset supply assumptions on research and analysis by EPA. EPA has provided EIA with estimates of baselines and domestic and international "marginal abatement cost curves," or MACs, for various sources of GHG emissions and biogenic carbon sequestration. The MACs reflect the estimated economic GHG abatements that could be achieved from emission reduction projects, given a price or value on GHG emissions reductions. Such estimates tend to reflect the technical potential for emissions reductions with positive rates of return and do not reflect institutional and market factors affecting adoption of abatement and offset options. As a result, EIA has incorporated discounting and market penetration assumptions to reflect these factors. Such estimates are naturally subject to a great deal of uncertainty, particularly with regard to international offsets.

The availability and price of international offsets from energy- and non-energy-related projects will depend on the global supply of and demand for emission reductions. The U.S. demand for offsets will compete with the demand for emissions abatement outside the United States, which, in turn, will depend on the emissions reduction commitments undertaken by other countries. Under ACESA, covered entities can submit project-level or sector-level offsets from developing countries that have established agreements with the United States to ensure that requirements for monitoring and verification are fulfilled. Under Sec. 728, covered entities may also submit allowances from approved countries that have established cap-and-trade systems of comparable stringency and scope. Allowances supplied under Sec. 728 do not count against offset limits and are not subject to any quantitative limits initially.

The potential supply of offset credits and allowances to the United States is derived based on the excess supply of potential abatement for the world, relative to the assumed demands for abatement based on stated or assumed emissions reduction commitments. Given that the capped sources of emissions under ACESA are primarily energy-related CO_2, the supply of CO_2 abatement from the Group 1 developed countries would potentially qualify as a source of comparable allowances. However, countries having equally stringent caps could face similar compliance costs at the margin, possibly limiting the potential for international allowance trading. Therefore, no net trade in international allowances was assumed.

International abatement supply is based on EPA-provided MACs for CO_2, other GHGs, and forestry/agriculture. In processing the MACs to obtain offset supply, EIA applies discounts and market penetration assumptions to reflect the market response to the technical abatement potential. EPA has disaggregated GHG abatements into two regional categories: Group 1 nations (Europe, Canada, Japan, Australia, and New Zealand) and Group 2 nations (the rest of world, excluding United States).

To reflect world competition for offset supplies, the international abatement market is assumed to establish a floor price, above which excess abatement supplies can penetrate the U.S. market in the form of offset credits from developing countries and, potentially, allowances from countries assumed to have comparable caps in place. A floor price, or international GHG abatement price excluding the United States, is estimated by combining annualized abatement supplies and abatement demand and solving for the market price each year. This approach allows the U.S. market for allowances to be treated somewhat independently from the world market and allows offset supplies to the United States to be restricted to developing countries, as specified in the bill.

The assumed international abatement demand is defined as international baseline emissions minus stated or hypothetical commitments to various emissions levels (Table B2). The reference emissions baseline shown is based on estimates originally provided by EPA and used in several previous EIA studies, but the non-U.S. energy-related CO_2 growth rates through 2030 have been updated to reflect the CO_2 projections in the EIA *International Energy Outlook 2009* (*IEO2009*) Reference Case, which does not reflect any international commitments to cap GHGs.

Table B2. Assumed International Abatement Demand, Excluding the United States
(million metric tons carbon dioxide equivalent)

	Reference Emissions		Policy Assumption		Cap		Abatement		
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Total
1990	8188	16268	Reference	Reference	8188	16268	0	0	0
1995	8403	18002	Reference	Reference	8403	18002	0	0	0
2000	8619	19736	Reference	Reference	8619	19736	0	0	0
2005	8848	21535	Reference	Reference	8848	21535	0	0	0
2010	8697	24778	5.0% below 1990	No Policy	7778	24778	919	0	919
2015	8851	27069	8.3% below 1990	No Policy	7508	27069	1343	0	1343
2020	9051	29503	16.6% below 1990	No Policy	6828	29503	2223	0	2223
2025	9089	31942	16.6% below 1990	2020 levels	6828	29503	2260	2439	4699
2030	9118	34303	26.6% below 1990	2020 levels	6010	29503	3108	4799	7908
2035	9214	36720	26.6% below 1990	2020 levels	6010	29503	3204	7217	10421
2040	9340	39196	36.6% below 1990	2020 levels	5191	29503	4149	9693	13842
2045	9471	41470	36.6% below 1990	2020 levels	5191	29503	4280	11967	16246
2050	9601	43743	46.6% below 1990	2020 levels	4372	29503	5229	14240	19470

Under ACESA, allowable sources of international offset credits are from developing countries that have established bilateral or multilateral agreements with the United States to ensure the offset requirements of the bill are fulfilled. For this analysis, it is assumed that the Group 2 countries will be deemed developing countries and that their participation will increase gradually over time as reflected by imposing a gradual market penetration function to their offset supplies. In the case of offsets from reduced deforestation, the bill specifies substantial additional regulatory requirements, such as agreements on national baselines, technical capacity to monitor, measure, report, and verify forest carbon fluxes, and institutional capacity to reduce deforestation, such as strong forest governance. These requirements will likely reduce the potential sources of forestry offsets to a subset of Group 2 countries. As a result, the technical potential of forestry-related abatement from Group 2 countries as provided by EPA has been discounted by 50 percent and a slower rate of market penetration has been applied than with other offset abatement supply sources.

Table B3 displays the assumed supply schedule of international offset credits, given these considerations. Both the gross Group 2 offset supply and the supply net of international abatement demand are shown, given the estimated international floor price for GHG abatement. The latter schedule (net supply) represents the supplies assumed to be available to the United States.

Depending on how international offsets are regulated and how fast the requisite international agreements or arrangements are formed, the potential availability of low-cost international offsets could be substantially different (greater or smaller) than assumed. In the ACESA High Offsets Case, the maximum allowable quantity of international offsets was assumed to be available in every projection year at the allowance price of that year.

Allowance Banking and Borrowing

To reflect banking incentives and trading arbitrage, allowance prices escalate at a rate no higher than 7.4 percent per year in real terms during intervals when allowance balances are held. This rate reflects the average cost of capital in the electric power sector, where a significant share of emissions reduction investments is expected to occur.

ACESA calls for increasingly stringent emissions caps beyond 2030, the forecast horizon for NEMS. Meeting these post-2030 caps will require significant emission reductions outside the electricity sector, the predominant source of early emissions reductions, and increase future price pressure, absent significant technological breakthrough in transportation and other uses that are dependent on fossil fuels. As a result, EIA assumes that covered entities and traders will amass a substantial allowance bank balance by the end of 2030. Based on recent modeling work by the EPA to evaluate ACESA impacts, an approximate average allowance balance of 13 BMT in 2030 was estimated across various scenarios they considered, an increase of cumulative abatement of roughly 50 percent above the minimum required under ACESA through 2030. This level of allowance banking is consistent with the greater difficulty of complying with the increasingly stringent post-2030 caps under continued growth in population and the economy. While the level of banking would also depend on other economic assumptions, such as the availability and cost of international offsets, the 13-BMT-balance assumption was applied in all but one of the cases analyzed. In the ACESA High Banking Case, where banked allowances were assumed to rise to 20 BMT, approximating the highest level observed in EPA's ACESA cases.

Table B3. Assumed Gross and Net Supply Schedule of International Offsets from Developing Countries

(million metric tons CO_2-equivalent)

Gross Group 2 Offset Supply					
	Potental Gross Quantity of Offsets Supplied (millon metric tons CO2 equivalent)				
Price (2000 dollars per tonne CO2)	2010	2015	2020	2025	2030
$0.0	0	0	0	0	0
$0.3	71	41	151	264	327
$3	131	97	294	684	992
$5	185	156	454	1106	1611
$8	229	234	622	1762	2630
$11	273	335	855	2578	3932
$14	322	459	1160	3578	5320
$20	388	727	1955	6120	8232
$27	455	1083	3062	9384	11361
$34	527	1507	4270	12248	14244
$41	603	2036	5602	14782	16206
$48	685	2680	6951	16922	17760
$55	772	3444	8248	18881	19263
$61	861	4208	9322	20521	20584
International Floor Price (2000 dollars per tonne CO2)	$13.15	$12.68	$11.81	$10.80	$15.81
International Abatement Demand at floor price (million metric tons CO2 equivalent)	308.3	404.2	937.1	2523.3	6200.3
Offset Supply, Net of International Abatement Demand					
	Potental Net Quantity of Offsets Supplied (millon metric tons CO2 equivalent)				
Price (2000 dollars per tonne CO2)	2010	2015	2020	2025	2030
$0.0	0	0	0	0	0
$0.3	0	0	0	0	0
$3	0	0	0	0	0
$5	0	0	0	0	0
$8	0	0	0	0	0
$11	0	0	0	55	0
$14	14	54	223	1054	0
$20	80	323	1017	3596	2032
$27	147	679	2125	6861	5161
$34	218	1103	3333	9725	8044
$41	295	1632	4665	12259	10005
$48	376	2276	6014	14399	11560
$55	464	3040	7311	16358	13062
$61	553	3803	8385	17998	14384

Treatment of Allowance Prices in Energy Prices

Under ACESA, the allowance obligations are imposed on an upstream basis, on producers and importers rather than end users, for all emissions from petroleum and a portion of natural gas sold by LDCs to uncovered entities. Allowance obligations for coal and natural gas covered entities in the industrial and electric power sectors are imposed on a downstream basis. This mixed regulatory approach has implications for how allowance costs are reflected in the modeling of delivered energy prices.

- The allowance holding requirement on covered entities for their coal-related and natural-gas-related CO_2 emissions is an incremental opportunity cost of using coal. For modeling purposes, the allowance cost was added to the delivered price of coal and natural gas to reflect the opportunity cost faced by these covered entities.

- For petroleum and uncovered natural gas regulated upstream, it is assumed that the allowance costs associated with the related CO_2 emissions are passed through in the delivered prices, with some exceptions.

- CO_2 emissions from refineries' direct fuel combustion of petroleum-based fuels would be subject to the allowance requirement. However, the incremental cost of these allowances is not explicitly reflected in delivered petroleum prices, as the Petroleum Market Module of NEMS is not structured to represent such costs explicitly.

- To reflect the bill's allowance allocations to electricity and natural gas LDCs for rebates to end users, average delivered prices are adjusted to reflect the rebates. Consumers receiving such rebates are assumed to treat their net average energy cost as the price basis for fuel-related decisions.

Additional details on modeling treatment of specific elements of the cap-and-trade provisions and other bill provisions are presented below for each modeling area.

Buildings Sector

The ACESA legislation contains several provisions designed to reduce energy use in buildings and to provide credit for buildings-related renewable electricity generation. The programs include codes and standards as well as direct funding from the sale of allowance aimed at increasing the energy efficiency in buildings. The buildings sector energy efficiency provisions directly modeled in NEMS include the following:

Building Codes (Section 201)

Section 201 establishes Federal building codes for both residential and commercial buildings, with provisions to improve the code every several years. This provision is funded with 0.5 percent of the total emissions allowances and is implemented in both the NEMS residential and commercial demand modules.

All of the improvements in commercial building codes are relative to the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) code 90.1-2004 and are assumed to be feasible. The building code efficiency improves by 30 percent upon enactment of the bill and by 50 percent in 2015, with 5-percent incremental improvements to the 2015 code every 3 years thereafter. It is assumed that the codes are phased in over 5 years following State adoption, reflecting the time it takes States to fully comply with each revision of the building code.

The improvements in residential building codes are relative to the International Energy Conservation Code (IECC) 2006. Similar to the commercial sector implementation, a 30-percent improvement in the code occurs with the enactment of the bill, with subsequent increments identical to those for commercial buildings over the projection period. Each code improvement, following State adoption, is assumed to require 5 years for all the States to fully comply; however, each of the nine Census divisions complies consistent with the historical level of building code compliance in each State.[18]

Existing Building Retrofit Program (Section 202)

Section 202 establishes the Retrofit for Energy and Environmental Performance (REEP) program which is funded by allowance allocation revenues as specified in section 782(g). Because individual States determine the amount of money to spend on various sectors of the economy (buildings, transportation, industry, etc) and the fact that allowance revenue streams and allocations for this provision change over the projection period, the energy savings impacts of this provision are subject to great uncertainty. For this analysis, it is assumed that $2 billion per year is available to retrofit residential buildings and that the investment and energy savings per house are comparable to EIA's previous analysis of the impact of weatherization funding included in ARRA.[19] For commercial buildings, it is assumed that funding is available to improve the shell efficiency of existing buildings by an additional 1 percent relative to the Reference Case by 2030.

Standards (Sections 211 and 212)

- Outdoor lighting standards effective 2011 to 2015
- Hot and cold water dispensers effective 2012
- Hot food holding cabinets effective 2012

The impact of the above standards is relatively modest. In the residential sector, the preponderance of lighting fixtures are located inside the house and many outdoor fixtures use traditional incandescent bulbs, which are already covered by aggressive efficiency standards under the Energy Independence and Security Act of 2007. The commercial sector accounts for outdoor stationary lighting such as roadway lighting, parking lots, billboards, airport runways, etc., which account for only about 8 percent of all lighting use in the United States.[20]

Rebates for Natural Gas and Oil Customers (Sections 782b and 782c)

Sections 782b and 782c allocate a relatively small portion of the overall emission allowances to oil and natural gas customers specifically for energy efficiency programs. In the buildings sector, these provisions are assumed to take the form of rebate programs for the purchase of energy-efficient furnaces and boilers.

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[18] Each State was given a "score" from 1 to 5 and weighted by housing permits to calculate a Census division average. The relative score for each State was derived from American Council for an Energy-Efficient Economy (ACEEE), *The State Energy Efficiency Scorecard for 2006*, June 2007.
[19] For more detail on the assumptions, see http://www.eia.doe.gov/oiaf/servicerpt/stimulus/index.html.
[20] Navigant Consulting Incorporated, *U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate*, September 2002.

Buildings sector participation in the Renewable Electricity Credit program that is part of the ACESA Clean Energy Title is directly modeled as discussed below.

Industrial Sector

Title I, Subtitle B, Section 115 promotes the commercial deployment of carbon capture and storage (CCS) technologies. After review of the state of the current technology, it was determined that the industrial CCS provision in the proposal would not be readily adopted by industry. This technology as it applies under the stipulations of the provision would require very large investments to retrofit existing facilities (or add new ones) and substantial land areas at an industrial site to capture the CO_2. Space is always limited at industrial facilities and the addition of new land would ultimately add a high "real-estate premium" to adoption of these systems. Many industries already producing pure CO_2 streams that could be supplied for CCS but these streams are already sold as a valued-added secondary product in the food industries and for enhanced oil recovery, among others. Consequently, it is assumed that industrial non-refining CCS would not penetrate that market through the projection period.

Title I, Subtitle C, Sections 123 and 125 provide financial assistance to automobile manufacturers to facilitate the manufacture of plug-in and other advanced technology vehicles. In the manufacture of vehicles, the platforms used and designed to manufacture standard vehicles are the same as those to manufacture plug-in and other advance technology vehicles. As such, the energy efficiency trends for the transportation equipment industry (NAICS 336) are assumed to be unchanged relative to the *AEO2009* Reference Case.

Title I, Subtitle H, Section 173, establishes several Centers for Energy and Environmental Knowledge and Outreach. Each center is to provide technical assistance, including energy savings assessments for industrial establishments. The proposed increased funding for energy savings assessments programs is expected to accelerate the penetration of energy efficiency measures and options in industries. To model this, the industrial demand module (IDM) of NEMS used the industrial sector high technology assumptions of *AEO2009*.

Title II, Subtitle D establishes various energy efficiency standards and programs for industries. The design and implementation of these standards and programs are yet to be decided. Due to this lack of information, no model changes were made to accommodate this part of the bill. Title II, Subtitle D, Sections 244 and 245 establishes a rebate and incentive programs designed to increase industrial motor efficiency. These were not adequately defined in the proposal and therefore no changes pertaining to the rebate and programs were made in the IDM. Nevertheless, the motor model remains an economic and technology choice system, and as such, any changes in industrial production and energy prices will impact the projected energy use in motors in industry.

The allocation of carbon allowances in the IDM has been applied as prescribed by the bill. These allowances are allocated to energy-intensive industries only, as indirect emissions allowances in 2012 and 2013 and full emissions allowances (direct and indirect) for the remaining timeframe. This allocation is, however, phased out beginning in 2025 as mandated in the proposal. To accurately reflect the lack of CO_2 emissions coverage for small industrial emitters in the early years of the cap-and-trade regime, a bifurcation of natural gas consumption was applied to the IDM for calendar years 2014 and 2015.

Transportation Sector

ACESA includes several provisions that are related to transportation, specifically, Sections 121-130 and Sections 221-224. However, none of these provisions have been incorporated into NEMS because they call for (a) analysis and not action, (b) the creation of programs without any specific measures that can be modeled in NEMS, or (c) are of such limited nature that they are not deemed large enough to impact transportation trends significantly.

- Section 121 mandates utilities to complete studies assessing the future electrification of the U.S. transportation fleet.

- Section 122 calls for the establishment of a program by which the Secretary of Energy can provide financial assistance to State or local governments for the demonstration of plug-in hybrid electric vehicles.

- Section 123 establishes a program by which the Secretary of Energy can provide financial assistance to automobile manufacturers to facilitate the manufacture of plug-in electric drive vehicles.

- Section 124 grants various emissions credits to the manufacture of alternatively-fueled vehicles.

- Section 125 provides loans to manufacturers of advanced vehicle technology.

- Section 126 amends the term "renewable biomass."

- Section 127 calls for the promotion of an open fuel standard and allows regulations to require each light-duty automobile manufacturer to produce a minimum percentage of fuel-choice-enabling automobiles.

- Section 128 amends diesel emissions regulations.

- Section 129 provides loan guarantees for the construction of renewable fuel pipelines.

- Section 221 calls for studies to propose changes to the emissions standards for heavy-duty vehicles, non-road vehicles, and aircraft engines.

- Section 222 calls for States to produce plans and create goals for the reduction of GHG emissions from transportation.

- Section 223 establishes within EPA a SmartWay Transport program to quantify, demonstrate, and promote transportation efficiency programs.

- Section 224 allows the Secretary of Energy to change State vehicle fleet requirements.

New Fuel Economy and Tailpipe Emissions Standards for Light-Duty Vehicles

President Obama unveiled a plan for tougher vehicle fuel economy standards that would require passenger cars to reach a fleet average of 39 miles per gallon and light trucks to reach a fleet average of 30 miles per gallon in model year 2016. The President has called for EPA and the National Highway Traffic Safety Administration to jointly produce these new standards as both a footprint based Corporate Average Fuel Economy and a tailpipe emissions standard. Since the policy change was only recently announced by the President and has not been formally implemented, the new fuel economy standards are only included in a sensitivity case for ACESA.

In the sensitivity case, the new fuel efficiency standards have been incorporated into NEMS that meet and slightly exceed the President's targets for model year 2016. The revised standards do not start in NEMS until 2012, as fuel economy standards for model year 2011 have already been promulgated by the National Highway Traffic Safety Administration. Standards are assumed to remain the same after model year 2016.

Macroeconomic

In all cases, MAM assumes exchange rates remain at the Reference Case levels. EIA assumes, as has been customary in several historical responses by the Federal Reserve, that the Federal Reserve will use a modified Taylor rule which will decrease interest rates in the face of rising unemployment. MAM takes all appropriate energy price and quantity variables from NEMS and converts them into IHS Global Insight aggregate energy measures.

Specific to the ACESA analysis, MAM implemented two major modeling changes: one pertaining to energy-intensive industries and the other to redistributing carbon allowance revenues back to the economy. As part of the H.R. 2454 bill, section 782 (e) allocates shares of allowances to trade- and energy-vulnerable industries. In MAM, these industries are impacted by various industrial fuel prices as well as overall changes in final demands. In the ACESA analysis, the energy-intensive industries react to pre-tax industry fuel prices, rather than post-tax prices under the assumption that when the industries receive the allocated allowances, the revenue will enable them to restructure their production processes to ameliorate the impact of rapidly rising energy prices.

MAM redistributes a certain portion of total allowance revenue. The following list includes the revenues being collected and redistributed by the model: Section 726 Strategic Reserve, Section 781, Supplemental Reserves, Section 782 (d) Low Income Allocation; Section 782 (g) Investment in Energy Efficiency and Renewable Energy; Section 782 (g) 1 f Investment in Energy Efficiency and Renewable Energy; Section 782 (g) Investment in Energy Efficiency and Renewable Energy (2) building codes; Section 782(h) Clean Energy Innovation Centers; Section

782(i) Clean Vehicle Technology; Section 782(k) Investment in workers; Section 782 (l) Domestic Adaptation; Section 782 (m) Wildlife and Natural Resource; Section 782 (m) Wildlife and Natural Resource; Section 782 (n) International Adaptation; Section 782 (o) International Clean Technology; and Section 782 (r) Consumer Climate Change Refund. MAM treated Section 782 (d) low income allocations as transfer payments, Section 782 (n) and (o) (international transfer of allocations) as other Federal government transfers to the rest of the world. Sections 782 (g) (h) (i) (k) (l) (m), Section 726 and Section 781 were treated as Federal government non-defense spending. Section 782 (r) which distributed funds post-2025 were treated as lump-sum personal tax rebates. All of the other allowances specified in H.R. 2454 went to energy-producing or -distributing entities or were given to energy-intensive industries and were not collected or redistributed by MAM. Changing the level of non-defense government expenditures insured that the Federal deficit at full employment was unchanged from the Reference Case across all ACESA cases. The uses of the carbon allowance revenues as stipulated by H.R. 2454 were modeled; however to the extent that the resulting change in government expenditures were lower than the actual amounts specified by the bill, other non-defense government expenditures would have to be reduced to insure unchanged Federal deficits over time.

Electric Power and Coal

Renewable Electricity Credits

Section 101 establishes a program requiring retail electric suppliers to submit renewable energy credits and electricity savings equal to a percentage of their annual electricity sales beginning in 2012. Distributed renewable generation facilities are issued 3 Federal renewable electricity credits for each megawatthour of renewable electricity generated with the granting of triple credits to be reviewed for adjustment in 2014 and every 4 years thereafter. It is assumed that the adjustment reviews result in an adjustment to 1 Federal renewable electricity credit per megawatt hour issued to distributed generation facilities starting in 2014. However, distributed renewable generators placed in service during a year when triple credit is granted continue to receive triple credit for 10 years. This provision is directly modeled in the buildings sector but is expected to have minimal impact on buildings sector renewable generation because the requirements of the cap-and-trade program in ACESA lead to sufficient renewable generation capacity in the power sector to meet the renewable electricity standard targets.

Carbon Capture and Sequestration

Section 114 outlines a CCS demonstration program that is to be run by the private sector, under the lead of the Electric Power Research Institute and funded by small fees on the distribution of fossil-fired electricity. The fees range from 0.22 mills per kilowatthour for natural-gas-fired electricity to 0.43 mills per kilowatthour for coal-fired electricity. The goal of this 10-year, $10-billion program is to support 5 commercial-scale CCS or conversion technology projects. The small fees on fossil-fired electricity distribution specified in this section are accounted for in the cases analyzed for this report and are assessed for the years 2010 through 2019.

Section 115 adds Section 786 "Commercial Deployment of Carbon Capture and Sequestration Technologies" to Section H of Title VII of the Clean Air Act. This section establishes a program to distribute bonus GHG emission allowances to new projects in the electricity and industrial sectors to help defray the costs associated with equipment and infrastructure needed to capture and sequester CO_2 emissions produced from the combustion of fossil fuels at these facilities. To be eligible for the bonus allowances allocated for this program, the project must derive at least 50 percent of its energy input from coal and/or petroleum coke. The first 6 gigawatts of approved capacity under this program are eligible to receive a $90 bonus allowance for each metric ton of CO_2 captured and sequestered. Beyond the initial 6 gigawatts of capacity with CCS, an additional 66 gigawatts are eligible for bonus allowances on the basis of a reverse auction administered by EPA or, at EPA's discretion, an alternative program for distributing the program's remaining bonus allowances. Only 1 gigawatt of retrofitted CCS capacity at existing plants is eligible for bonus allowances allocated under this section. Qualified CCS projects are eligible for 1.75 percent of allowances established according to section 721(a) for the years 2014 though 2017, 4.75 percent of allowances for the years 2018 and 2019, and 5.0 percent of allowances for the years 2020 through 2050.

This program is represented within the analysis for this report by reducing the estimated costs of new coal-fired generating capacity by the value of the bonus allowances that the plant would be eligible to receive. The amount of new coal-fired generating capacity projected within a given forecast scenario is determined by a number of factors such as the costs and availability of electricity from other generating technologies, the availability of international and domestic offsets, and the projected levels of electricity demand.

Section 116 adds a new Section 812 "Performance Standards For New Coal-Fired Power Plants" to Title VIII of the Clean Air Act, which specifies that new power plants authorized under State or Federal law to derive at least 30 percent of their energy input from coal and/or petroleum coke will initially be required to capture and sequester a minimum of 50 percent of their potential CO_2 emissions. The CCS requirement rises to 65 percent for plants built in 2020 or later. Additionally, based on reviews of the standards to be completed by the EPA Administrator at 5-year intervals, and beginning no later than 2025, CCS requirements would be increased to levels higher than 65 percent if higher capture and storage rates are determined to be reasonably achievable. In the analysis completed for this report, new coal-fired power plants with CCS are assumed to capture and sequester 90 percent of their potential CO_2 emissions.

Peak Demand Reductions (Section 143)

This section requires States to determine and publish peak demand reduction goals for load-serving entities with a baseline above 250 megawatts. The Secretary, with the Federal Energy Regulatory Commission (FERC) and the North American Electricity Reliability Council, will develop a methodology for measurement and verification of demand response. The FERC report 2009 National Demand Response Potential Assessment should be used to help determine peak reduction goals. The load-serving entities must reduce peak load by 2012 and further by 2015, by amounts determined by each State.

This program is represented in the analysis by assuming that peak demand will be reduced by 3 percent by 2020, instead of the 1 percent assumed in the Reference Case due to ARRA.

Allocation of Emission Allowances (Sec. 782)

Section 782 (a)(1) allocates allowances for the benefit of electricity consumers, starting at 44 percent of total allowances in 2012 and falling over time through 2029, after which no further allowances are given out. Section 782 (a)(2) allocates a separate 0.5 percent specifically to small load distribution centers. For modeling purposes, these allowances are added together and treated as one allocation. Section 783 describes the method of distributing the allowances, with the majority going to LDCs to be used exclusively for the benefit of retail ratepayers. Up to 10 percent of the allowances under this section can be given to merchant coal generators, based on their qualifying emissions through a base historical period.

These allocations are accounted for in the electricity pricing calculations. The allowances given to merchant coal generators are calculated based on historic emissions, and the value of the allowances in each year would offset the rising fuel costs in the affected regions. The remaining allowances are shared to the regions based on a combination of historic emissions and overall electricity sales, as described in Section 783(b)(2) and Section 783(b)(3). The revenue from this allowance allocation is assumed to go to reduced distribution costs, lowering the distribution component of electricity price to all consumers.

e

ENVIRONMENTAL DEFENSE FUND

finding the ways that work

Cutting Global Warming Pollution For a Dime A Day

Key Findings from Recent Government Analyses of Current Climate Legislation

Last week, the Congressional Budget Office published its analysis of the costs of climate legislation currently under consideration by the House — H.R. 2454, the American Clean Energy and Security Act (ACES). Earlier this week, the Environmental Protection Agency released its own analysis of the bill.

Taken together, these two studies represent the most credible analyses available of the economic impacts of this legislation. The EPA study is a comprehensive macroeconomic analysis of the costs of reducing carbon emissions over the entire duration of the program, from 2012 through 2050. The CBO study, meanwhile, is a more focused analysis of the potential impacts in the year 2020, based on detailed data on current production and consumption patterns in the U.S. economy.

It's crucial to note that these estimates all correspond to the cost of climate policy compared to business as usual. But in reality, the business-as-usual scenario doesn't exist. It's a fantasy-land scenario in which there are no economic costs of unchecked climate change – and we all know that's there's no such thing. The EPA and CBO analyses, like almost all economic modeling studies, looks at only one side of the ledger: the costs of action, but not the benefits of averting the catastrophic consequences of climate change.

Here are a few highlights.

Economic growth

EPA's new analysis shows that <u>the U.S. economy will grow strongly under the proposed legislation.</u> According to the EPA forecasts:

- In the year 2015, the estimated impact on GDP of HR 2454, relative to a no-policy case, ranges from a slight reduction of 0.4% to an <u>increase</u> of 0.1%.

- By the year 2030, the U.S. economy will be 70 percent larger than it is today. The estimated impact of HR 2454 is a reduction of 0.4% to 1% relative to the baseline.

- On an annual basis, the estimated impact will be imperceptible: just two- to four-hundredths of a percentage point (0.02 - 0.04 %).

- To put that in perspective, if the American economy will reach $23 trillion in January 2030 if we do nothing to address climate change, it will get there sometime between February and May with a carbon cap.

Household impacts

While macroeconomic analyses can give a sense of the big picture, it may be more useful to hone in on the household-level impacts. What are the costs for the average American family? The EPA and CBO analyses gives us a clear sense of what the costs of the bill are likely to be, and they are small.

- The CBO estimates that the cost to the average household in the year 2020 will be just $175 — less than fifty cents a day.

- Because of provisions designed to protect low- to moderate-income families, the impacts are even smaller at the low end of the income scale. CBO estimates that the poorest one-fifth of U.S. households would see a *benefit* of $40 a year through tax refunds and assistance with utility bills. The next fifth of households, meanwhile, would pay just $40.

- The EPA's analysis, using more dynamic models of the macroeconomy, comes in with even lower costs. According to the EPA's estimate, for example, the average cost to households in the year 2015 will be just $21 to $70.

- In fact, over the entire span of the bill, the EPA's estimated average annual cost is just $80 to $111 per household, in present value. That is just 22 to 30 cents a day for the average American family — less than the cost of a postage stamp.

- In fact, on a per-person basis, EPA's estimated average annual cost amounts to only 9 to 12 cents — about a dime a day.

These estimates include the entire net costs to households of the program, taking into account higher prices for fossil fuels as well as savings from energy efficiency and the hundreds of billions of dollars (in present value) that the legislation returns to households over the program.

Energy costs

EPA provides detailed estimates of energy costs in its analysis. While these are included in the household cost figures given above, the effect of climate legislation on energy prices is often of particular interest in its own right.

- According to EPA's modeling, average electricity prices are essentially unaffected by the legislation until the year 2030, when they are estimated to be 14% higher than under the business-as-usual case. Even then, however, electricity *bills* would be less than 3% higher than the reference case, as a result of the savings from investments in energy efficiency that the legislation will promote.

- What's more, in the years before 2030, EPA projects that the average household's electricity bills will go *down* as a result of the legislation. For example, in the year 2020 the average household's electricity bills under HR 2454 are projected to be 8 % below their levels in the no-policy case.

- As a result, overall household energy expenditures (excluding gasoline) would also fall, by about 7 % in 2020 relative to the no-policy case.

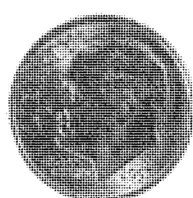
- Finally, while gasoline prices would rise, the effect is tiny. In the year 2020, the EPA forecasts that gasoline prices will be only 14 cents per gallon higher than they would be without any policy. On average, that's just 2 cents per gallon per year relative to the no-policy case. That's an imperceptible change, especially compared with the large swings in gasoline prices we have seen in recent years — sometimes as large as a dollar over the course of a few months.

- The real concern with petroleum is our increasing dependence on foreign oil. EPA estimates that HR 2454 would save us roughly $20 billion annually over the next two decades.

In truth, this is old news. The EPA and CBO studies are completely consistent with everything else we know. The consensus among credible analysis is that the American economy will grow robustly while cutting carbon pollution and investing in a clean energy economy.

We're sure to hear a lot of numbers that have been cherry-picked from reports issued by whatever modelers-for-hire can be found to support the desired point. Forecasts are not crystal balls: they are only as good as the assumptions that go into them. And some of the assumptions used to get some of the numbers that will be floating around are just simply not credible.

The EPA in particular has set the gold standard in economic analysis by using two of the most credible, transparent, and peer-reviewed models available. And the bottom line from that analysis is that for about a dime a day we can solve climate change, help get our economy off foreign oil, and invest in a clean energy economy.



Statement of Sonny Richardson,

On Behalf of the National Association of Home Builders

"Legislative Hearing Regarding American Clean Energy Security Act"

Subcommittee on Energy and the Environment
House Energy and Commerce Committee

April 24, 2009

Chairman Markey, Ranking Member Upton, and distinguished members of the Subcommittee, my name is Sonny Richardson and I am a home builder from Tuscaloosa, Alabama. I am pleased to present testimony today on behalf of the 200,000 members of the National Association of Home Builders (NAHB), representing every aspect of the residential construction industry – single family and multi-family builders, light commercial builders, remodelers, material suppliers, appliance manufacturers, real estate professionals, and housing finance interests.

Facing the brunt of the economic downturn and the worst housing market since the Great Depression, I can personally attest to the devastating losses and historic declines facing our industry. Falling from a height of two million new homes constructed in 2006 to less than 500,000 projected for 2009, the housing industry has suffered overwhelming setbacks that continue to force our small business members (comprising 80% of our association) out of business. This affects the ability of our industry to deliver the next generation of housing to the market that will be more energy and resource efficient. Because NAHB members build about 80% of all the new homes in the United States, we must necessarily influence the manner in which energy efficiency and sustainable technologies are introduced into our nation's housing stock. As one of those promoting energy efficiency and affordability in my industry, I am excited to testify today about both the challenges and opportunities facing us as we work collectively to evaluate and improve efficiency in the residential sector.

The challenge of climate change affects everyone, including the residential construction industry. NAHB members are responding in numerous ways, contrary to assertions that builders generally oppose efficiency. NAHB invested millions of dollars in developing a national green building program and creation of the first and only *National Green Building Standard*™ approved by the American National Standards Institute (ANSI). Home builders embrace robust national policies to address today's environmental challenges and support effective measures to implement greater sustainability and efficiency in the broadest possible manner. This written statement explains the realities of the housing market and explains how the provisions in the *American Clean Energy and Security Act of 2009 Draft* (ACES Act Draft) to update state building energy efficiency codes (Section 201) may not achieve true energy savings, but are likely to impair affordability for millions of future residents of green and energy-efficient dwellings.

Residential Energy Consumption Realities

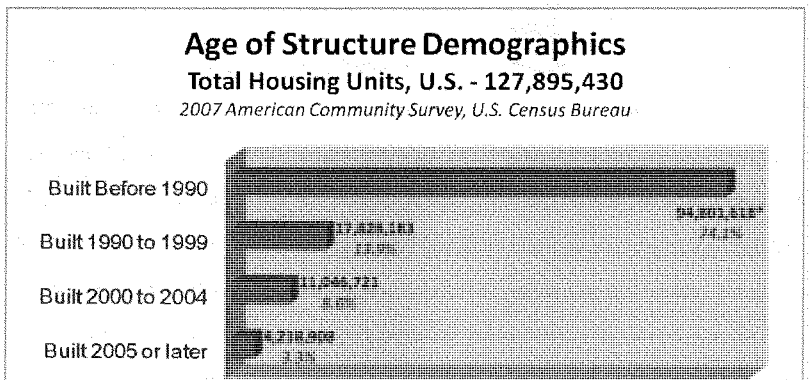
Although targeted as a major untapped reservoir of potential energy and greenhouse gas emissions (GHGs) savings, the residential sector has already moved at lightning speed to embrace energy efficiency and sustainability in new buildings. In fact, according to the Energy Information Administration (EIA), newer homes, i.e., homes built after 1991 – represent the smallest fraction, 2.5%, of all the annual national consumption in 2001.

Energy Consumption in 2001 in Trillions of Btu

Total	**96,498**	**100.00%**
Residential Sector	**20,228**	**20.96%**
Manufactured Housing	**1,301**	**1.35%**
Fossil Fuel Used to Generate Electricity	815	0.84%
Consumed by Residence	486	0.50%
Single Family and Multifamily Built before 1991	**16,498**	**17.10%**
Fossil Fuel Used to Generate Electricity	8,743	9.06%
Consumed by Residence	7,755	8.04%
Single Family and Multifamily Built 1991-2001	**2,429**	**2.52%**
Fossil Fuel Used to Generate Electricity	1,386	1.44%
Consumed by Residence	1,043	1.08%

Sources: Annual Energy Review by the Energy Information Administration; the 2001 Residential Energy Consumption Survey, Energy Information Administration.

This is important because it demonstrates the shortcomings of a policy approach that is designed to require aggressive increases in efficiency for new construction that ultimately may not deliver the greatest energy savings. The biggest return on efficiency investment in the residential sector would be realized by improving older homes, which according to the U.S. Census Bureau comprise 74.1% of the current U.S. housing stock:



* Modern energy codes were primarily unsued prior to 1992.

Because building codes and construction practices have improved over time, newer homes are dramatically more energy efficient. The ability to realize additional energy savings from an already super-efficient segment of the residential sector via building codes is extremely limited, and thus cannot be expected to deliver dramatic results in terms of greenhouse gas (GHG) emissions reductions or consumer utility savings. NAHB suggests that a much more robust approach to integrated energy efficiency in the residential sector is the best way to achieve the goals of reducing energy consumption and GHG emissions.

<u>The Role of Building Energy Codes</u>

I am an active participant in the code development process that occurs through the International Code Council (ICC) and can confirm that much of the rhetoric today about what building codes can do for energy savings, aimed at the public and policymaker alike, is terribly shortsighted. Some groups suggest that all concerns about the built environment and the GHG emissions attributable to it could easily be ameliorated with a few aggressive building code regulations. Others recognize that energy efficiency is more than just building codes and that greater focus is needed on sustainability and the overall performance of the home. Regrettably, facts about what is actually attainable through energy code requirements is often lost in broad platitudes while the true realities of residential energy consumption and the development of effective policies to address it holistically are cast aside.

It is true that codes are consistently improved through a normal cyclical process whereby stakeholders from every interested party – enforcement officials, environmentalists, builders, etc. – convene to discuss the merits of certain changes, eventually producing a revised code for adoption by state or local governments. It is false to assume that just requiring states or local governments to adopt arbitrary above-code compliance targets for all new construction is going to translate into deliverable energy savings. A state or local government may decide to adopt an aggressive energy code for new construction, but without resources to enforce it, or without resources to address existing homes, such requirements are not meaningful on a broad scale.

The implementation of energy codes at the local level and the need for geographic flexibility is one reason why the federal government is limited in terms of what it can expect state and local governments to deliver. Under the police powers of the U.S. Constitution, states are given the authority to determine appropriate building codes within their jurisdiction. Some states confer this authority to local municipalities and set up a framework whereby climatic and geographic concerns can be specifically addressed in their individual jurisdictions. For example, Florida needs the flexibility to require hurricane impact resistant building standards, and similarly may require more efficient air conditioning equipment because these are specific geographic demands that make sense for that state. Whereas requiring the same codes in Michigan – i.e., hurricane impact resistant building standards and high-efficiency air conditioners – might be completely illogical.

Because geography, climate, and other conditions impact the combined structural safety, soundness, and energy performance of residential structures in various parts of the U.S., it is necessary to have the flexibility to adopt national model codes that fit specific needs. While the federal government should encourage greater efficiency through incentives (e.g., Section 45L New Energy Efficient Home Credit), it would falter in local code enforcement and risk bypassing specific local needs. In this regard, it could also supersede existing public-private programs (e.g., Energy Star®), and overlook successful green building programs. Provisions like Section 201 of the ACES Act Draft that require states to adopt above-code targets without reference to the robust sustainability framework of more environmentally-sound green building not only leave states or local areas out of compliance with federal law, but essentially downgrades sustainability for the sake of code compliance. NAHB believes it should never be the case that a state must choose between such extremes, especially since green homes save both energy *and* resources.

State and local governments need to be actively engaged in developing code requirements that are appropriate for the structures built within their jurisdictions. The federal government needs to support them with resources for code implementation that saves energy and resources while not endangering public health or adversely affecting affordability for consumers that generally bear the largest burden (as a percentage of income) of energy costs, i.e., lower and moderate-income families. The federal government can embrace greater efficiency in our nation's housing stock in a manner that supports housing affordability so that everyone, at all price points, can enjoy a green and energy-efficient home.

Energy Efficiency and Affordability

One of the most important aspects of the current code development process is the ability to consider costs and benefits to improvements in efficiency stringencies and to determine paybacks in terms of energy savings for certain features based on initial costs. These "payback periods" are important for demonstrating those changes that can deliver more immediate consumer savings in terms of initial costs versus changes that may take decades or longer to payback in energy savings. For example, a change in the lighting requirements from incandescents to fluorescents or LED, which NAHB supports, has a 1-2 year payback to the consumer in terms of energy savings versus upfront costs while increasing attic insulation may take decades or never payback. In this regard, the law of diminishing returns applies, i.e., only minimal additional energy savings can be realized by an incremental increase in any given energy efficiency measure.

However, when the frame of reference is shifted from the payback in energy savings to the consumer, for example, to a "life cycle" of a building or home, per Section 201, these reasonably-determined cost considerations for the consumer are bypassed entirely. In this instance, a consumer would be responsible for paying for efficiency features that may payback over the entire time a home exists, rather than realizing any meaningful energy savings during the time in which he or she might occupy the home (often less than 10 years).

It is also possible that some changes in efficiency features may never payback during the lifetime of the structure. For example, requiring double-pane low-e windows in southern Florida has an energy savings payback of over 300 years. NAHB suggests adding language, as passed by the House in previous energy legislation – H.R. 3221, Roll Call No. 832, August 4, 2007 – that states that changes to the codes must be "*technically feasible and economically justified based on available appliances, technologies, materials, and construction practices*." This will help accommodate changes that put the consumer first in energy savings paybacks and energy efficiency.

Despite the dramatic downturn and the virtual halt of new construction in the U.S., NAHB believes that we must preserve affordability for the new homes that must be built once the market turns around. In this regard, if the government adopts the approach of mandatory energy codes embraced in a "life cycle" costing approach, there is great potential risk for harm to marginal first-time home buyers. These buyers are typically characterized by lower incomes, limited up-front cash for down payments, with intent to purchase relatively modest-priced homes. Ironically, these lower-income marginal buyers are also the ones that share the larger burden of energy costs as a percentage of income and therefore often cannot and should not be expected to wait decades for future paybacks from efficiency features.

Mandated criteria that increase up-front costs for new homes in exchange for a future payback may work well at the top of the market, or even in the average case, yet have the effect of pricing out marginal first-time buyers at the lower end of the market. NAHB does not believe the assertion that a broad public policy objective should be achieved on the backs of a relatively narrow segment of the market with limited resources. Similarly, NAHB hopes that Congress will not impose policies that increase costs for newer, more energy efficient homes in a manner that relegates lower and moderate-income families to less-efficient older housing stock.

Energy Performance

Some argue that building envelope improvements – often accomplished through code change requirements – are the best way to address building efficiency because it is assumed that builders will simply absorb the additional costs. The truth is that builders cannot simply push thousands of dollars of efficiency upgrades onto consumers, particularly in instances where consumers are not even demanding such features, and expect to remain competitive in the market. Many of the features that consume energy in a home are not chosen by builders or covered by codes, but ultimately affect the home's energy performance and can, in some cases, offset envelope improvements that are covered by codes.

The exponential growth in electronics use and plug-connected equipment in a home will have dramatic affects on a home's ultimate energy performance. In April 2008, the Electric Power Research Institute (EPRI) presented information at an event on Capitol Hill that showed that by the year 2030, 30% of all the energy consumed in a home will be "plug load" capacity[1]. The proliferation of big screen televisions, computers, cell phone chargers, DVR's, and even

[1] Electric Power Research Institute, presentation by Arshad Mansoor, Ph.D. – *"Energy Efficiency Across the Electricity Value Change."* April 16, 2008 - Great Energy Efficiency Day, Washington, D.C.

digital photo frames will have major consumption implications that should be addressed. The growth of plug-connected usage in residential energy consumption threatens building performance and can easily offset energy savings from envelope and equipment improvements.

The Green Building Movement

NAHB's experience and support for voluntary energy efficiency and green predates many of the available green ratings systems today. Long before green was a part of every day lexicon, NAHB members were actively engaged in building green homes, as part of an organic process that has significantly reshaped residential construction. Aside from our members' work in efficiency programs, like Energy Star® and the Department of Energy's (DOE) Building America program, we have been long-standing pioneers in what is now known as the green building movement.

In the early 1990's, local builders began driving sustainable residential construction that incorporates a flexible framework to accommodate geography, resources, and energy efficiency. As the movement grew, NAHB members became more engaged and, in 1998, NAHB established a national group to work specifically on green building issues. By 2004, the industry, including over sixty stakeholders, began developing a set of national guidelines to recommend to builders how to incorporate ever-increasing sustainability benchmarks for compliance with green criteria. These became known as the National Green Home Building Guidelines.

However, as the need to develop a more reliable verification methodology became apparent, the members of NAHB agreed to work collaboratively with the ICC to undertake a rigorous standards-developing process that ultimately produced the first standard approved by the American National Standards Institute (ANSI) for green residential construction and remodeling in the United States – the *ICC-700 National Green Building Standard*™. The development of the *National Green Building Standard*™ is the most recent, and most robust, effort undertaken by the industry to set compliance markers for green building in the various aspects that comprise residential construction – single family, multifamily, remodeling, and land development.

The process began in early 2007 when a group of 42 stakeholders convened in Washington D.C. representing federal (U.S. EPA, DOE), state, and local governments, building code officials, design professionals, building supplier manufacturers, sustainable building interest groups, utilities, builders, and energy efficiency consultants [see Appendix A]. These experts worked together to develop rigorous, environmentally-sound, and defensible criteria for green residential construction incorporating the seven primary principles of sustainability: energy efficiency, water efficiency, resource efficiency, lot and site development, indoor environmental quality, global impact, and home owner education. After several revisions and over 3,000 public comments, the standard was approved by ANSI on January 29, 2009 and is the only green standard approved by a third-party Standards Developing Organization (SDO), (i.e., ANSI), for residential construction and remodeling in the U.S.

The *National Green Building Standard*™ complies with federal law requiring federal agencies to utilize voluntary consensus standards in the market when available. The National Technology Transfer Act of 1996 (P.L.104-113) states in Section 12 (d)(1) that:

> *In general.--Except as provided in paragraph (3) of this subsection, all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments.*

NAHB understands the importance of providing a viable, rigorous, and consensus-based alternative to the plethora of privately developed green rating systems flooding the market as the green movement continues to grow. NAHB believes the federal government similarly understands the importance of this concept. By passing this law, it has appropriately identified the need to recognize those standards that have undergone the lengthy and rigorous approval procedures inherently equipped with adequate safeguards against undue private or corporate influence, confirmed by approval from unaffiliated SDOs.

One very important aspect of green building is, of course, energy efficiency. To be sure, green building embodies more than just energy efficiency, however this is a major component of building performance; primarily because of the costs associated with it, i.e., utility bills. Due to concerns about the variability of consumer behavior and how consumption habits could potentially offset some efficiency gains in the envelope, the developers of the National Green Building Standard™ made sure to underscore the importance of educating homeowners about maintenance and home operation with a requirement in the standard. This adds value by educating the consumer about how personal conservation habits in the home are equally as important as improving the construction techniques of the home itself.

Existing Homes & Remodeling

Beyond green building, the shift in demand for remodeling for greater energy efficiency is a rapidly growing trend in the residential sector. NAHB supports the approach and intent of Section 202 in the ACES Act Draft legislation will provide direct dollars to consumers to improve the energy efficiency of existing homes and buildings. Section 202 does not mandate specific above-code targets, but rather approaches older homes holistically and directs the limited resources of the federal government directly at the largest part of the energy consumption problem, i.e., older homes. NAHB urges a similar approach be employed in new construction in lieu of the requirements for arbitrary code targets proposed in Section 201.

Additionally, existing homes offer a great opportunity for savings by simply replacing less efficient appliances with Energy Star® rated models. This can save an average of 30 percent over standard appliances and deliver meaningful energy savings in the form of decreased utility bills for consumers. While some efficiency upgrades are more costly than others (e.g., new heating/cooling systems versus replacing incandescent bulbs) each has the potential to save energy for the consumer operating an existing home. All of these components are important for having an integrated approach towards energy efficiency. NAHB hopes that Congress will focus on the biggest part of the energy loss problem in the residential sector while supporting incentives to encourage above-code programs for new construction.

Conclusions and Recommendations

Improvements in residential energy efficiency and the growing green building movement are absolutely changing the dynamics of the housing market today. In some instances, the changes and improvements may be occurring at a slower pace than desired by policymakers and others, but claiming that nothing is occurring towards improved efficiency and sustainability is patently false. The reality is that a mix of incentives, consumer education, changes in construction technologies, and adoption of locally-enforceable and meaningful efficiency measures with a focus on older homes is needed to drive greater efficiency in the residential sector.

There are many opportunities for the government to work with home builders to achieve the goal of improved building efficiency in the ACES Act Draft legislation. NAHB recommends the following changes to address integrated energy efficiency in both new and existing homes:

- Modify the language in Section 201 to accommodate efficiency gains outside of code-controlled envelope requirements as builders reach to achieve increases in future editions of the energy code. Avoid allowing DOE to modify ICC codes or ASHRAE standards that may not accommodate every state's climate demands simultaneously or equally.
- Congress must restore its commitment to energy incentives that help offset upfront costs of efficiency upgrades. To do this, Congress should extend, or make permanent, Section 45L, Section 25C, Section 25D, and Section 179D of the tax code.

- Congress should employ the approach set forth in Section 202 to provide consumers with direct funding to improve efficiency of existing homes and buildings and consider applying a similar policy towards new construction.
- Lastly, Congress should consider embracing a broad possible green building policy and provide consideration for homes that achieve compliance with green building standards that have been approved by the ANSI, such as the *ICC-700 National Green Building Standard*™ for residential construction, remodeling, and land development. This recognition is important not only because the standard complies with federal law governing consensus standards (National Technology Transfer Act P.L. 104-113), but also because energy code targets by themselves cannot accommodate the more robust sustainability framework of green building, which achieves greater environmental performance as a whole over energy efficiency alone.

Appendix A

Consensus Committee on the
National Green Building Standard™

Representatives from the following organizations, companies, and government offices participated in the development of the criteria as approved by the American National Standards Institute (ANSI) for the ICC-700 2008 National Green Building Standard™:

American Forest & Paper Association
American Gas Association
American Institute of Architects
Bowen Collins and Associates, Consulting Engineers
Brick Industry Association
Build Green New Mexico
Building Owners and Managers Association (BOMA) International
Building Quality
City of Dearborn, Michigan, Department of Building & Safety
City of Denton, Texas, County Building Inspections
City of Keene, New Hampshire
City of Rio Rancho, New Mexico
City of St. Paul, Minnesota
City of Scottsdale, Arizona
CNIC Housing – Commander, Navy Installation Command, U.S. Navy
ConSol
Edison Electric Institute
Fairfax County, Virginia, Department of Public Works
Gas Appliance Manufacturers Association (GAMA)
Green Builder, LLC
Green Building Initiative, Portland, Oregon
Green Built Michigan (Lansing)
Gypsum Association
K. Hovnanian Homes/Landover Group
Manufactured Housing Institute
NAHB Land Development Committee
National Multi Housing Council
North American Insulation Manufacturers Association
Plastic Pipe and Fittings Association
Plumbing Manufacturers Institute
Portland Cement Association
State of California, Department of Housing and Community Development
Steel Framing Alliance
Sustainable Buildings Institute
Town of Parker, Colorado
United States Environmental Protection Agency
United States Department of Energy
U.S. Green Building Council
Veridian Homes
Village of Arlington Heights, Illinois
Whirlpool Corporation
Winchester Homes, Inc.

Testimony from the
National Association of Home Builders

United States Senate
Committee on Environment & Public Works

"Legislative Hearing on S. 1733 – *Clean Energy Jobs and American Power Act*"

October 29, 2009

Written Statement

Overview

On behalf of the 200,000 members of the National Association of Home Builders (NAHB), we appreciate the opportunity to provide testimony on S. 1733 – *Clean Energy Jobs and American Power Act of 2009*. Our industry's desire to improve energy efficiency in the residential sector through the development of the first and only National Green Building Standard™ approved by the American National Standards Institute (ANSI) is one way that we have confirmed our commitment to building greener, more energy- and resource-efficient homes. NAHB has also worked collaboratively with many environmental and business leaders to support extensions and expansions of energy tax credits incentivizing the construction of super-efficient new homes and commercial buildings. The housing industry is working hard to promote additional efficiency gains in new construction by supporting increases to the national model energy efficiency code (2006 IECC) by at least 30% within two years and supports improving energy efficiency in *all* aspects of a home, including those not covered by building codes – e.g., plug loads, appliance efficiency, and resident behavior.

Section 163 of S. 1733 attempts to rework the entire structure of the national model energy code development process for new buildings. NAHB believes, however that this restructuring would benefit from additional modifications and clarifications related to the establishment of targets and implementation. While some measure of building efficiency will likely be included in a final compromise bill, NAHB strongly opposes the approach set forth in the Waxman-Markey climate change bill – H.R. 2454 – *The American Clean Energy Security Act*. H.R. 2454 supersedes states' rights, imposes expensive and arbitrary targets with aggressive implementation dates, and bypasses consideration of energy savings paybacks to consumers with reasonable cost increases that ultimately impairs housing affordability. NAHB looks forward to working with the Committee to develop an effective energy efficiency policy that includes extending critical efficiency incentives and avoids unnecessary cost increases for newer, more energy-efficient housing.

Section 163 – Energy Efficiency in Building Codes

NAHB strongly supports voluntary energy efficiency programs, green building, and the successful Energy Star® for Homes program. NAHB also participates in and supports the development of national model building and energy codes covering a variety of building safety, health, and energy efficiency issues. The development of national model energy codes, operated and published by the International Code Council (ICC), consists of minimum standards for energy efficiency that are updated every three years and are adopted and enforced by states or local governments. Each new edition of the model energy code (International Energy Conservation Code) is required to be reviewed by the Department of Energy to determine if it is sufficiently more energy efficient than the previous version. The next IECC edition is scheduled to be published in 2012. This process routinely produces ever-increasing efficiencies in minimum code compliance, but is restructured under Section 163 and replaced with a rulemaking by either EPA or another agency head, as determined by the President. Section 163 also calls for annual reports to Congress on the status of the implementation of such rule.

NAHB supports the approach of not codifying efficiency minimums in federal legislation that states or local areas should be required to enforce, as these decisions are currently made by and should remain with state or local officials. The idea of allowing everyone an opportunity to provide information on the cost-effectiveness of specific increases in minimum energy codes, implementation barriers, and other enforcement realties through a rulemaking process is intriguing. Ironically, this is exactly the way the current code development process functions, including participation from the federal government via the Department of Energy. Nevertheless, because Section 163 does not dictate specific and arbitrary numbers or percentages, the approach acknowledges that consideration of cost-effectiveness and practical implementation factors are important and must be reviewed. The Waxman-Markey approach in H.R. 2454 does not provide this type of flexibility.

NAHB does, however, question the ability of the EPA Administrator to promulgate and implement regulations covering building energy code targets, as proposed under Section 163. Currently, the Department of Energy is required by law to make determinations on the national model energy codes once a new edition has been published by the code developing organization (i.e., ICC). The Department of Energy has not released a code determination since 2000, despite its integral participation in the code development process and its primary role in helping develop national building efficiency benchmarks. Given that the Department of Energy has been unable to complete this work, NAHB wonders if the EPA is equipped to undertake such responsibilities with potentially less expertise in the area of building energy code development. Similarly, because the turn-around on building code updates is generally very fast, it is questionable whether the EPA could replace the duties and undertake the responsibilities of updating building energy codes that is currently managed by an organization with thousands of building professionals and a network of enforcement officials already in place.

The Wrong Approach – H.R. 2454 – *American Clean Energy Security Act*

NAHB believes that Section 201 of the Waxman-Markey climate change bill, H.R. 2454 – *American Clean Energy Security Act* is entirely the wrong approach to improving building energy efficiency. H.R. 2454 codifies a mandatory 30% increase above the 2006 IECC by 2010, 50% increase by 2014, and a 75% increase by 2029 for all new home construction in the United States. Under H.R. 2454, states that fail to adopt and enforce these minimums will lose emissions allowances under cap-and-trade on a sliding scale for every year of non-compliance, as well as lose other energy-efficiency related funding under the bill. If states refuse to adopt and enforce the minimums within a year, then the federal government will have the authority to intervene and enforce the federal energy code minimums in state and local areas. There is no capacity for states or local areas to choose a lower target, despite variances in climate or other locally-specific needs that may make compliance difficult.

Attached to this Statement is a copy of NAHB's testimony before the House Subcommittee on Energy and the Environment from April 24, 2009, detailing NAHB's concerns with the draft Waxman-Markey bill, federal intervention into the building code development process, and the plethora of affordability problems that arise from arbitrary and expensive federal energy code mandates.

Conclusion

NAHB supports a number of energy efficiency and green building programs for residential construction and has been partners with the government in improving energy efficiency in new homes for more than three decades. The housing industry initiated the creation of the only ANSI-certified National Green Building Standard™ and works collaboratively with many of the leading environmental and business leaders to support extending incentives for super-efficient new home construction, as well as for retrofitting existing housing stock. NAHB members are committed to providing the next generation of green and energy-efficient homes and looks forward to working with the Committee and Congress to develop an effective building efficiency policy that addresses all housing types and the components of homes that use the *most* energy and are not covered by building code mandates – e.g., plug loads, appliances, and consumer choice.

TESTIMONY OF MARLO LEWIS
SENIOR FELLOW IN ENVIRONMENTAL POLICY
COMPETITIVE ENTERPRISE INSTITUTE
LEGISLATIVE HEARING ON S. 1733, CLEAN ENERGY JOBS AND AMERICAN POWER ACT

SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE
OCTOBER 28, 2009

Thank you, Chairman Boxer and Ranking Member Inhofe, for the opportunity to submit written testimony on climate change, energy, and national security – the focus of Panel 2 of today's hearing.

Increasingly, proponents of cap-and-trade legislation argue that climate change is a major threat to U.S. national security. My testimony develops two points: (1) the supposed national security risks of climate change are generally overblown, improbable, or even imaginary; (2) the national security risks of climate change policies are real and substantial and likely outweigh those of climate change itself.

In the Beginning

"Few discoveries are more irritating," wrote Lord Acton, "than those which disclose the pedigree of ideas." At the risk of irritating Committee Members, I must point out that climate change first came to public attention as a national security concern when, in October 2003, the Pentagon published a study by Peter Schwartz and Doug Randall titled *Imagining the Unthinkable: An Abrupt Climate Change Scenario and Its Implications for United States National Security.*[1]

In *Imagining the Unthinkable*, the authors hypothesize what might happen to the global economy and international stability if increased ice melt and precipitation due to global warming disrupt the Atlantic Thermohaline Circulation (THC) and Earth's climate deteriorates into an ice age.

Unsurprisingly, the authors conclude that the end of the world as we know it would have massive "implications" for U.S. national security. In page after pulse-pounding page, Schwartz and Randall describe a world convulsed by famine, food riots, water shortages, energy shortages, trade wars, displaced populations, and armed conflict within and among nations.

Schwartz and Randall worried that the THC could shut down as soon as 2010. How many scientists worry about this today? There is no evidence that the THC is weakening or likely to shut down in the foreseeable future.[2] It's not even clear that a disruption of the THC would have the climate-wrenching effects Schwartz and Randall assume.[3]

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[1] *Imagining the Unthinkable: An Abrupt Climate Change Scenario and Its Implications for United States National Security* a report by Peter Schwartz and Doug Randal http://www.climate.org/PDF/clim_change_scenario.pdf

[2] Boyer T., et al. 2007. Changes in fresh water content in the North Atlantic Ocean 1955-2006. Geophysical Research Letters, Vol. 34, L16603, doi: 10.1029/2007GL030126; Latif, M. et al. 2006. Is the thermohaline circulation changing? *Journal of Climate* **19**: 4631-4637; Kerr, R. A., 2006. False Alarm: Atlantic Conveyor Belt Hasn't Slowed Down After All, *Science*, **314**, 1064, doi: 00.1126/science.314.5802.1064a; World Climate Report,

In *An Inconvenient Truth*, former Vice President Al Gore worries that a 20-foot wall of water could sweep across the world's coastal communities. Millions upon millions of people "would have to be evacuated," "would be forced to move," "would be displaced," he warns.[4] This could happen, Gore hypothesizes, "If Greenland melted or broke up and slipped into the sea – or if half of Greenland melted or broke up and slipped into the sea."[5] If such a catastrophe were remotely plausible, it would be a national security problem of gigantic proportions. But it is not plausible.

Greenland is shedding ice at the rate of about 27 cubic miles per year.[6] Greenland has approximately 719,000 cubic miles of ice.[7] This means Greenland is shedding ice at the rate of 4/10ths of 1 percent *per century*. In the IPCC's mid-range emissions scenario (A1B), Greenland ice loss contributes between 1 centimeter (cm) and 8 cm of sea-level rise in the 21st Century; in the high-end emissions scenario (AFI), Greenland ice loss contributes between 2 cm and 12 cm of sea-level rise by 2100.[8] Over the 21st Century, sea-level rise due to Greenland ice loss is likely to be measured in inches, not feet.

How long would it take to melt half of Greenland's ice? The IPCC estimates that Greenland would shed about half its ice if CO2 concentrations rise to 1,100 parts per million – about four times pre-industrial levels – and remain so elevated for 1,000 years.[9]

In *An Inconvenient Truth*, Gore argued that "moulins" – cracks that channel melt-water from the surface to the bedrock – could lubricate the ice sheet, dramatically accelerating its breakup and slide into the sea. A study in *Science* magazine lays that fear to rest as well. An entire melt-water lake 8 kilometers long and 4 meters deep poured down a moulin in less than 2 hours, at a flow rate exceeding that of Niagara Falls. Yet, *Science* magazine reports, "For all the lake's water dumped under the ice that day, and all the water drained into new moulins in the following weeks, the ice sheet moved only an extra half meter near the drained lake."[10] For perspective, the Greenland ice sheet is about 2,400 kilometers long and almost 1,000 kilometers wide near its northern margin.[11]

Since the Earth emerged from the Little Ice Age, sea levels have risen about 7 to 9 inches. This has had impacts on coastal infrastructure including military installations. However, to my knowledge, no historian has ever concluded that sea-level rise was an important factor in any of the great battles of the 20th Century. The IPCC projects between 7 and 23 inches of sea-level rise in the 21st Century. Even at the high-end of this range, sea-level rise would likely not be a major influence on the course of human events.

March 15, 2005: http://www.worldclimatereport.com/index.php/2007/08/22/ocean-circulation-slowdown-false-alarm/ ; World Climate Report, August 2, 2007: http://www.worldclimatereport.com/index.php?s=thermohaline+circulation

[3] Seager, Richard: "Climate mythology: The Gulf Stream, European climate and Abrupt Change," http://www.ldeo.columbia.edu/res/div/ocp/gs/

[4] Al Gore, *An Inconvenient Truth* (Rodale; Melcher Media, 2006), pp. 204-206.

[5] Id. p. 196.

[6] Luthcke, S. B. et al. 2006. Recent Greenland Ice Mass Loss by Drainage System from Satellite Gravity Observations. *Science*, Vol. 314, No. 5803, pp. 2086-2089.

[7] Volume of Earth's Polar Ice Caps, http://hypertextbook.com/facts/2000/HannaBerenblit.shtml.

[8] IPCC, Climate Change 2007, The Physical Science Basis, Chapter 10, Table 10.7, p. 820.

[9] Id., summarizing Ridley et al. (2005), p. 830.

[10] Richard Kerr, "Greenland Ice Slipping Away But Not All That Quickly," *Science*, Vol. 320, April 18, 2008.

[11] Greenland Ice Sheet, Encyclopedia Britannica, http://www.britannica.com/EBchecked/topic/245306/Greenland-Ice-Sheet.

Threat Multiplier Hype

As scenarios of abrupt climate change and catastrophic sea-level rise have lost credibility, cap-and-trade advocates have pushed a more nuanced national security rationale for suppressing carbon-based energy use. This is the notion that climate change is an important "threat multiplier." Global warming, they contend, will increase the frequency and severity of drought, crop failure, famine, and coastal flooding, which will impoverish and displace millions, producing conflict, instability, and terrorism.[12]

This is all very dubious. Climate change impact assessments hugely depend on assumptions about climate sensitivity, which in turn depend on assumptions about the relative strength of positive and negative climate feedback mechanisms. A new observational study by MIT scientists Richard Lindzen and Yong-Sang Choi finds that negative feedbacks dominate the tropical atmosphere's response to increases in sea-surface temperature.[13] Lindzen and Choi conclude that a doubling of greenhouse gas concentrations over pre-industrial levels will produce 0.5°C of warming — about six times less warming than the IPCC's "best estimate."

If climate sensitivity is as low as Lindzen and Choi infer from the data — or even if it is double their estimate – there is no climate "crisis" and no "threat multiplier."

In addition, climate impact assessments depend on assumptions about future technology, wealth, and adaptive capability. History indicates that economic liberty, free trade, and technological innovation will continue to improve the human condition regardless of climate change.

According to the IPCC, the second half of the 20th century was "likely the warmest 50-year period in the Northern hemisphere in 1300 years" (IPCC, AR4, WGI, Chapter 9, p. 702). That's open to debate.[14] Nonetheless, for the sake of argument let's grant the premise. What have been the observed effects on human welfare?

In the United States, heat-related mortality and air pollution have declined since the 1970s, while crop yields and average lifespan have increased.[15] Global warming, where is thy sting?

Okay, one might say, that's the United States, the world's wealthiest country. What about developing countries — how is global warming affecting them?

According to many cap-and-trade proponents, global warming makes extreme weather events more frequent and severe. So, weather-wise, is the world becoming a more dangerous place?

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[12] See CNA study, "National Security and the Threat of Climate Change," released in April 2007. http://securityandclimate.cna.org/

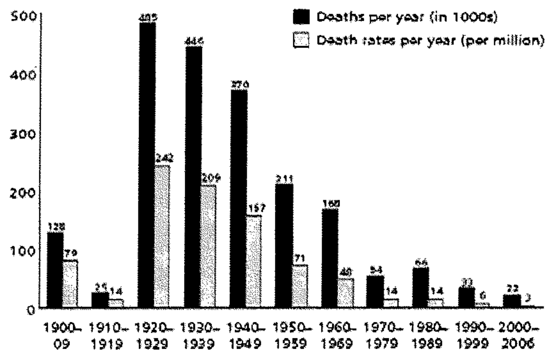
[13] Lindzen, R. and Choi, Y-S. 2009. On the determination of climate feedbacks from ERBE data, Geophysical Research Letters, Vol. 36, L16705, doi:10.1029/2009GL0396628, http://www.drroyspencer.com/Lindzen-and-Choi-GRL-2009.pdf.

[14] See *Climate Change Reconsidered: The 2009 Report of the Nongovernmental International Panel on Climate Change (NIPCC)*, published in 2007: http://www.nipccreport.org/chapter3.html

[15] World Climate Report blog, November 19, 2008: http://www.worldclimatereport.com/index.php/2008/11/19/why-the-epa-should-find-against-endangerment/

Quite the reverse. Globally, aggregate mortality and mortality rates related to extreme weather events of all kinds plummeted 95% and 98.5%, respectively, from 1920 to 2006.[16] It is unreasonable to assume a reversal of this well-established trend.

Figure 1 **Global death and death rates due to extreme events, 1900–2006**



Note that in figures 1 through 4, data for the last period are averaged over seven years worth of data.
Sources: EM-DAT (2007); McEvedy and Jones (1978); WRI (2005, 2007)

Source: Indur Goklany, Deaths and Death Rates due to Extreme Weather Events: Global and U.S. Trends, 1900–2006, The Civil Society Coalition on Climate Change, November 2007.[17]

One of the principal ways climate change supposedly acts as a "threat multiplier" is to intensify drought and water shortages, leading to crop failure, famine, and armed conflict within and among nations. A remarkable column in *Nature* magazine by Wendy Barnaby deflates this fashionable alarum.[18]

Barnaby, editor of People & Science, the journal of the British Science Association, had written a book about biological warfare, and the publishers suggested she write a book about the coming century of "water wars."

At the outset, she assumed that water scarcity is a significant source of armed conflict in the world – a pervasive problem just waiting to be 'threat multiplied' by climate change. The book

[16] Indur Goklani, *Death and Death Rates Due to Extreme Weather Events: Global and U.S. Trends, 1900-2006.* http://goklany.org/library/deaths%20death%20rates%20from%20extreme%20events%202007.pdf
[17] Indur Goklani, *Death and Death Rates Due to Extreme Weather Events: Global and U.S. Trends, 1900-2006* http://goklany.org/library/deaths%20death%20rates%20from%20extreme%20events%202007.pdf
[18] Wendy Barnaby, Do nations go to war over water? Nature 458, 282-283 (19 March 2009), http://www.nature.com/nature/journal/v458/n7236/full/458282a.html

was to include a history of water wars, but, as she dug into her topic, she found there wasn't much history to write about. "Cooperation, in fact, is the dominant response to shared water resources," she discovered. The data are overwhelming:

> Between 1948 and 1999, cooperation over water, including the signing of treaties, far outweighed conflict over water and violent conflict in particular. Of 1,831 instances of interactions over international fresh water resources tallied over that time period (including everything from unofficial verbal exchanges to economic agreements or military action), 67% were cooperative, only 28% were conflictive, and the remaining 5% neutral or insignificant. *In those five decades, there were no formal declarations of war over water* (emphasis added).

It is true that many nations are water-stressed, but this has not meant that their people must either perish or go to war to seize another country's water supplies. Usually, it means that countries cooperate and import "virtual water" in the form of agricultural produce. It takes lots more water to grow crops than it does to supply households with drinking water. So where water is scarce, people tend to substitute grain imports for home-grown produce. Israel, Jordan, and Egypt are a case in point:

> Israel ran out of water in the 1950s: it has not since then produced enough water to meet all of its needs, including food production. Jordan had been in the same situation since the 1960s; Egypt since the 1970s. Although it's true that these countries have fought wars with each other, they have not fought over water. Instead, they all import grain. As [U.K. social scientist Tony] Allan points out, more 'virtual' water flows into the Middle East each year embedded in grain than flows down the Nile to Egyptian farmers.

Climate change-related drought would pose challenges to resource managers but should not lead to armed conflict where nations are free to cooperate and trade.

Barnaby's conclusion is worth reproducing in full:

> Book or no book, it is still important that the popular myth of water wars somehow be dispelled once and for all. This will not only stop unsettling and incorrect predictions of international conflict over water. It will also discourage a certain public resignation that climate change will bring war, and focus attention on what politicians can do to avoid it: most importantly, improve the conditions of trade for developing countries to strengthen their economies. And it would help to convince water engineers and managers, who still tend to see water shortages in terms of local supply and demand, that the solutions to water scarcity and security lie outside the water sector in the water/food/trade/economic development sector. It would be great if we could unclog our stream of thought about misleading notions of 'water wars.'

Environmental researcher Indur Goklany provides additional evidence that climate change is unlikely to be an important threat multiplier. Climate change supposedly increases the frequency of floods as well as droughts. Obviously, the worst and most destabilizing thing droughts and floods can do is kill people. Are deaths from droughts and floods going up or going down?

Goklany finds that "deaths from droughts have declined 99.9% since the 1920s, and 99% from floods since the 1930s."[19]

What of the future? Maybe the amount of warming experienced so far isn't so bad, but what if the rate of warming spikes upward over the next several decades?

Probably the most pessimistic assessment of the economic damages from a warming at the high end of the IPCC forecast range is the UK Government's *Stern Review on the Economics of Climate Change*.[20] In the Spring 2009 issue of *Regulation* magazine, Goklany dissects the *Stern Review* and finds that even in its worst-case scenario, developing countries in the late 21st Century are prosperous by today's standards.[21] Goklany's analysis may be summarized as follows:

- According to the *Stern Review*, the 5th-95th percentile estimates of losses in welfare due to climate change under the warmest IPCC scenario (which might lead to a 4°C increase in global temperatures from 1990 to 2085) range from 0.9% to 7.5% in 2100, with a mean loss of 2.9%. By 2200, under this extreme scenario, estimated losses range from 2.9% to 35.2%, with a mean loss of 13.8%.
- Goklany shows that even if one assumes the *Stern Review*'s 95th percentile loss estimate under the warmest scenario, developing countries' net welfare (after accounting for climate change) would increase from $900 per capita in 1990 to $61,500 in 2100 and $86,200 in 2200 (all in 1990 U.S.$).
- For context, Goklany notes that in 2006, GDP per capita was $19,300 for industrialized countries, $30,100 for the United States, and $1,500 for developing countries.
- Thus, despite its best efforts to paint a gloomy picture, the *Stern Review*'s own numbers tell us that, regardless of climate change, global welfare will improve dramatically over the next two hundred years, and developing country adaptive capacity will far surpass that of industrial countries today — even if the high-end IPCC warming scenario comes to pass.

The figure below illustrates Goklany's analysis:

[19] Indur Goklany, A Bad Climate for Development – Rebuttal to the Economist, October 8, 2009, citing Goklany, Death and Death Rates Due to Extreme Weather Events, http://wattsupwiththat.com/2009/10/08/a-bad-climate-for-development-rebuttal-to-the-economist/

[20] *Stern Review on the Economics of Climate Change*, released on October 30, 2006 by the Office of Climate Change: http://www.hm-treasury.gov.uk/sternreview_index.htm

[21] Indur Goklani, "Discounting the Future," *Regulation*, Spring 2009. http://goklany.org/library/Goklany%20Discounting%20the%20future%20Regulation%202009%20v32n1-5.pdf

Table 2

The Costs of Warming

Mean welfare per capita in 2100 and 2200 for developing and industrialized countries, adjusting for the costs of climate change from market effects, nonmarket (i.e., environmental and public health) effects, and the risk of catastrophe, per the Stern Review's 95th percentile estimate of costs

A.	1990	2100			
Scenario	Actual	A1FI	A2	B2	B1
DEVELOPING COUNTRIES					
GDP per capita, no climate change	$900	$66,500	$11,000	$18,000	$40,200
Maximum cost of climate change*	0	$5,000	$600	$500	$800
Net welfare per capita, with climate change	$900	$61,500	$10,400	$17,500	$39,400
INDUSTRIALIZED COUNTRIES					
GDP per capita, no climate change	$13,700	$107,300	$46,200	$54,400	$72,800
Maximum cost of climate change*	0	$8,000	$2,400	$1,500	$1,500
Net welfare per capita, with climate change	$13,700	$99,300	$43,800	$52,900	$71,300

B.	1990	2200			
Scenario	Actual	A1FI	A2	B2	B1
DEVELOPING COUNTRIES					
GDP per capita, no climate change	$900	$133,000	$22,500	$36,000	$80,400
Maximum cost of climate change*	0	$46,800	$6,300	$4,500	$7,600
Net welfare per capita, with climate change	$900	$86,200	$16,700	$31,500	$72,800
INDUSTRIALIZED COUNTRIES					
GDP per capita, no climate change	$13,700	$214,600	$92,400	$108,800	$145,600
Maximum cost of climate change*	0	$75,500	$22,000	$12,700	$13,400
Net welfare per capita, climate change*	$13,700	$139,100	$70,300	$96,100	$132,200

SOURCE: [illegible]

Indeed, even if we go beyond the Stern Review's gloomiest projection, and assume that global warming will reduce global GDP 35.2% by 2100 (instead of by 2200), developing country per-capita GDP in 2100 is over $43,000 — more than twice industrial country per capita GDP in 2006.

Bang for Buck?

Even if climate change were an important threat-multiplier, that is no guaranty that cap-and-trade would be an effective response. Climate scientist Chip Knappenberger shows that reducing U.S. emissions 83% below 2005 levels by 2050 — the Kerry-Boxer emissions-reduction target —

would avoid less than 0.2°C of projected global warming by 2100.[22] That's an amount too small to be distinguished from the "noise" of inter-annual climate variability. Even if all industrial countries achieve the Kerry-Boxer target, that would avoid only 0.4°C of warming by 2100 — less than 10% of the projected rise in the IPCC's "fossil intensive" (A1FI) emissions scenario.

Cumulatively, the United States and its allies could end up spending trillions of dollars to achieve trivial reductions in projected climate change. As a national security strategy, Kerry-Boxer would yield no measurable bang for buck.

When cap-and-traders call global warming a national security issue, they mainly mean that climate change will aggravate a number of pre-existing threats – e.g., drought, hunger, malaria, coastal flooding — that already cause or contribute to instability and conflict. Goklany outlines a more promising way to address those conditions – an approach he calls "focused adaptation."[23]

Goklany shows that it is much more effective — and far cheaper — to tackle directly, with proven methods, the health and environmental threats that a changing climate might exacerbate than it is to address those threats indirectly via energy-rationing schemes. For example, the Kyoto Protocol, at a cost of $165 billion per year, might reduce deaths from malaria by 0.2% in 2085. In contrast, a $3 billion annual investment in proven anti-malaria methods could reduce malaria deaths by 75%, according to the UN Millennium Development Project.

Bjorn Lomborg's Copenhagen Consensus project comes to much the same conclusion.[24] Resources available to meet the world's biggest challenges are finite. Hence, Lomborg sensibly argues, policymakers should invest in those policies that will do the most good per dollar expended.

In 2004, Lomborg convened a panel of eight distinguished economists, including three Nobel Laureates, to answer the question, "What would be the best ways of advancing global welfare, and particularly the welfare of developing countries, supposing that an additional $50 billion in resources were at governments' disposal?" The panel commissioned "challenge papers" from 10 acknowledged authorities in different policy fields. The authors set out more than 30 policy proposals for the panel's consideration. The panel, the authors, and two outside experts in each field examined and debated the proposals during a week-long conference. The panel then ranked the proposals in order of desirability:

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[22] http://masterresource.org/?p=2367

[23] Indur Goklani, *What to Do about Climate Change*, CATO Policy Analysis No. 609, February 5, 2008. http://www.cato.org/pubs/pas/pa-609.pdf

[24] For more about the Copenhagen Consensus Center, see http://www.copenhagenconsensus.com/About%20CCC/About%20CCC.aspx

Project rating		Challenge	Opportunity
Very Good	1	Diseases	Control of HIV/AIDS
	2	Malnutrition	Providing micro nutrients
	3	Subsidies and Trade	Trade liberalisation
	4	Diseases	Control of malaria
Good	5	Malnutrition	Development of new agricultural technologies
	6	Sanitation & Water	Small-scale water technology for livelihoods
	7	Sanitation & Water	Community-managed water supply and sanitation
	8	Sanitation & Water	Research on water productivity in food production
	9	Government	Lowering the cost of starting a new business
Fair	10	Migration	Lowering barriers to migration for skilled workers
	11	Malnutrition	Improving infant and child nutrition
	12	Malnutrition	Reducing the prevalence of low birth weight
	13	Diseases	Scaled-up basic health services
Bad	14	Migration	Guest worker programmes for the unskilled
	15	Climate	Optimal carbon tax
	16	Climate	The Kyoto Protocol
	17	Climate	Value-at-risk carbon tax

All three climate policy proposals were deemed "bad investments." Costs would exceed benefits and the policies would save far fewer lives per dollar invested than would alternative policy proposals.

Because resources are finite, bad investments tend to crowd out good. Even if climate policies did no positive harm, they could undermine U.S. national security by (a) displacing investment in policies that more effectively enhance human welfare, and (b) diverting money, expertise, public attention, and political will from the kinds of threats our military forces and intelligence agencies actually know how to do something about.

In fact, however, climate policies have a high potential to *do positive harm* to U.S. national security.

The National Security Risks of Climate Change Policies

In testimony (p. 7) before a joint hearing (June 25, 2008) of the House Permanent Select Committee on Intelligence and the House Select Committee on Energy Independence and Global Warming, Dr. Thomas Fingar, Chairman of the National Council on Intelligence (NIC), stated that, "Government, business, and public efforts to develop mitigation and adaptation strategies to deal with climate change — from policies to reduce greenhouse gases to plans to reduce exposure to climate change or capitalize on potential impacts — may affect U.S. national security interests even more than the physical impacts of climate change itself."[25]

[25] Testimony of Dr. Thomas Fingar on the National Intelligence Assessment on the Security Implications of Global Climate Change to 2020," before the House Permanent Select Committee on Intelligence and the House Select Committee on Energy Independence and Global Warming, on June 25, 2008. http://globalwarming.house.gov/tools/2q08materials/files/0069.pdf

Those words provoked the ire of Chairman Ed Markey (D-MA), who demanded to know who at Bush's OMB inserted that verbiage into Fingar's testimony. Finger assured Markey that the entire testimony, including the offending sentence, reflects the consensus view of the U.S. intelligence community, and that OMB offered no comments on that portion of the text. (Incidentally, Fingar's testimony also said that climate change was "unlikely to trigger state failure in any state out through 2030," and that "the United States as a whole would enjoy modest economic benefits over the next several decades largely due to increased crop yields.")

Regrettably, Fingar's testimony did not explain how climate policies might affect U.S. national security interests "more than the physical impacts of climate change itself," nor did he elaborate in the back-and-forth with Chairman Markey. In general, the global warming debate lacks balance, with climate change risks highlighted, exaggerated, or even invented, and climate policy risks denied or ignored.

Let's then consider some of the ways climate policies might damage U.S. national security interests.

(1) Gas pains. The Romans used to say that an army travels on its stomach. For the past hundred years or so, however, armed forces have traveled on their fuel tanks. In the Afghan and Iraq wars, U.S. strategy plays to our comparative advantage in mobile forces.[26] Today's U.S. Army is the most fuel-intensive in history.[27]

At recent briefing sponsored by Partners for a Secure America (PSA), Admiral Dennis McGinn warned that the end of the current recession would usher in a return to a "volatile cycle of rising energy prices." Oil exceeded $140 a barrel in July 2008, and global demand could push oil prices back up to that level, he opined.

Agreed. But now suppose that on top of that, Congress enacts a cap-and-trade program. Such policies are *designed* to make carbon-based fuels more costly (see p. 2 of former CBO Director Peter Orszag's April 24, 2008 congressional testimony).[28] The Heritage Foundation estimates that the Waxman-Markey cap-and-trade program would increase motor fuel prices by 58% or $1.38/gallon by 2030.[29]

Next, layer on top of the price effects of cap-and-trade and resurgent global demand the effects of additional supply constraints imposed by other "clean energy" policies, such as:

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[26] Report by Jessica Leber for E&E on July 20, 2009: http://www.eenews.net/public/climatewire/2009/07/20/1

[27] Robert Bryce, "Gas Pains," *The Atlantic*, May 2005: http://www.theatlantic.com/doc/200505/bryce

[28] Statement of Peter Orzag on the Implications of a Cap-and-Trade Program for Carbon Dioxide Emissions before the Committee on Finance of the US Senate, on April 24, 2008. http://www.cbo.gov/ftpdocs/91xx/doc9134/04-24-Cap_Trade_Testimony.pdf

[29] David Kreutzer, Karen Campbell, William Beach, Ben Lieberman, and Nicholas Loris, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy Security Act*, Heritage Center for Data Analysis Report #09-04, August 6, 2009. http://www.heritage.org/Research/EnergyandEnvironment/cda0904.cfm

- moratoria on oil and gas exploration in the North Sea,[30] the Arctic,[31] and the U.S. Pacific coast;
- carbon tariffs[32] or low-fuel standards[33] that cut off imports of Canadian tar-sands oil;
- Clean Air Act New Source Performance Standards (NSPS) for carbon dioxide (CO2) emissions that discourage investments to expand refining capacity;[34]
- windfall profit taxes that deter U.S. oil companies from developing new supply sources;[35] and,
- prohibitions on the development of oil from the Rocky Mountain shale.[36]

If Congress enacts this green policy wish-list, including cap-and-trade, while global demand for petroleum products rebounds, we will all long for the days when gasoline cost "only" $4.00/gallon.

Everybody would feel pain at the pump, including the nation's largest energy consumer, the Department of Defense.[37] Although Congress would not allow U.S. armed forces to lack fuel in combat situations, soaring energy prices would put pressure on DOD to reprogram funds and cut fuel consumption – perhaps, for example, by reducing the frequency or scope of training exercises. Experts in the field should consider how a policy-induced "energy crunch" might impact DOD budgets for training, procurement, salaries, and benefits. So far, there has been no public discussion of this.

(2) Money is the Sinew of War. Economic strength is the foundation of military might. A strong industrial base made America the "arsenal of democracy" in two world wars. America won the Cold War in part because the Soviets went broke trying to match the Reagan-era defense buildup.

America cannot remain a great power with a second-rate economy. A dynamic economy not only supports investment in military forces and high-tech weaponry, it also promotes U.S. leadership in the world generally. Conversely, economic stagnation forces painful budgetary choices

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[30] "Norwegian bishop's proposal for oil moratorium runs into some flak, *Ecumenical News International*, 23 February, 2009. http://eni.ch/featured/article.php?id=2759

[31] As advanced by the Center for Biological Diversity, http://www.biologicaldiversity.org/programs/public_lands/energy/dirty_energy_development/oil_and_gas/index.html

[32] Possibility of carbon tariffs has triggered Canadian concern: http://www.tarsandswatch.org/canada-says-proposed-u-s-greenhouse-gas-tax-would-hurt-trade-lee-anne-goodman

[33] Nicola Jones, "Obama may be tough on Canada's tar sands,' published online in *Nature*, 13 February, 2009. http://www.nature.com/news/2009/090213/full/news.2009.103.html

[34] See *Washington Energy Report*, Troutman Sanders, September 5, 2008. http://www.troutmansanders.com/firm/media/mediadetail.aspx?media=964

[35] Advocated by non-profits like Public Citizen, http://www.citizen.org/publications/release.cfm?ID=7425

[36] See press release by the Natural Resources Defense Council, http://www.nrdc.org/media/2008/080722a.asp

[37] See Congressional Research Service report by Anthony Andrews, "Department of Defense Facilities Energy Conservation Policies and Spending," February 19, 2009. http://www.fas.org/sgp/crs/natsec/R40111.pdf

between guns and butter, and the associated "malaise" can sway public attitudes towards isolationism.[38]

Affordable energy is vital to economic growth. The cap-and-traders acknowledge this, sort of, when they blame high oil prices for contributing to our economic woes. But they don't acknowledge the inescapable implication: Because cap-and-trade policies are designed to make energy more costly, they can chill job creation and growth.

The Heritage Foundation estimates that Waxman-Markey would reduce cumulative GDP by $9.4 trillion from 2012 to 2030 and reduce net employment by 1.9 million in 2012 and 2.5 million in 2035.[39] Similarly, the National Association of Manufacturers/American Council for Capital Formation study estimates that, in 2030, Waxman-Markey would lower annual GDP by $419 billion to $571 billion and reduce net employment by 1.79 million to 2.44 million.[40]

All such studies depend on assumptions and are open to criticism. Nonetheless, the potential for carbon-suppression policies to weaken the economy by inflating energy prices is undeniable. Likewise, the potential for economic weakness to produce military weakness is undeniable. A "perfect storm" created by the convergence of Kerry-Boxer, the other anti-oil policies noted above, and resurgent global petroleum demand could produce one heck of an energy crunch, putting the economy into a tailspin.

The threat to the U.S. economy may be even greater than the Heritage Foundation's analysis suggests. The Heritage study analyzes the impacts of the bill's *explicit* emission reduction targets and obligations. However, Title VII, Part A of both bills contain language that could (1) encourage CO2 tort litigation against businesses smaller than those subject to the cap-and-trade program, and (2) pressure policymakers to move the goal posts – amend the legislation to make "350 the new 450" and tighten caps. For further discussion of this important issue, see my recent column on MasterResource.Org, the free-market energy blog.[41]

(3) Threat Multiplier. The global warming movement's top priority is to stop construction of new coal-fired plants[42] in order to reduce global emissions 50%[43] or more by 2050[44]. Yet,

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[38] http://www.rightwingnews.com/speeches/carter.php

[39] David Kreutzer, Karen Campbell, William Beach, Ben Lieberman, and Nicholas Loris, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy Security Act*, Heritage Center for Data Analysis Report #09-04, August 6, 2009. http://www.heritage.org/Research/EnergyandEnvironment/cda0904.cfm

[40] "Analysis of the Wasman-Markey Bill 'The American Clean Energy Security Act of 2009', Using The National Energy Modeling System," by the National Association of Manufacturers (NAM) and the American Council for Capital Formation (ACCF), August 2009. http://www.accf.org/media/dynamic/3/media_381.pdf

[41] Marlo Lewis, "Kerry-Boxer: Its Bite Is Worse Than Its Bark," Masterresource.Org, October 27, 2009, http://www.masterresource.org/2009/10/kerry-boxer-its-bite-is-worse-than-its-bark.

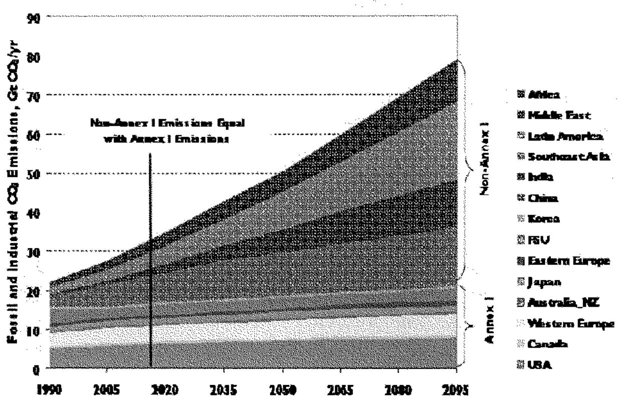
[42] See May 5, 2008 blog post at Climate Progress: http://climateprogress.org/2008/05/05/is-450-ppm-politically-possible-part-4-the-most-urgent-climate-policy-isnt-a-co2-price/

[43] AFP, "Halve global-warming pollution by 2050, Europe tells summit," September 24, 2007: http://www.turkishpress.com/news.asp?id=195474

[44] See European Parliament press release, October 23, 2007: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+IM-PRESS+20071022IPR12053+0+DOC+XML+V0//EN

banning new coal plants in developing countries could condemn large segments of humanity – the 1.6 billion people who have never flipped a light switch – to decades of deadly energy poverty.[45]

Approximately 90% of the growth in global emissions in the remainder of this century is projected to occur in developing ("Non-Annex I") countries.



Source: James Connaughton, Chairman, Council on Environmental Quality, Energy and Climate Policy, December 2007.[46]

Thus, absent breakthroughs that dramatically lower the cost of zero-emission energy, there is no way to achieve the 50% global emissions reduction target without suppressing energy consumption and economic growth in the world's poorest countries.

Thwarting developing countries' aspirations for a better life would not promote stability and peace! Global warming policy is potentially a big threat-multiplier.

(4) Trade war, U.S-China conflict. The EU/UN/Al Gore goal of reducing global emissions at least 50% by 2050 will require developing countries to limit their CO2 emissions to 1.3 tons per capita (see slide #11 of U.S. Chamber of Commerce economist Stephen Eule's Power Point presentation[47]). That's roughly equivalent to current per-capita CO2 emissions in Africa,[48] the

[45] http://www.openmarket.org/2009/08/24/policy-peril-segment-10-its-a-moral-issue/ and http://masterresource.org/?p=4483#more-4483

[46] http://belfercenter.ksg.harvard.edu/files/2007-12-12%20Connaughton%20Presentation%20FINAL.pdf

[47] Slide 11 can be viewed at: http://www.energyxxi.org/pages/February_2009__Vice_President_Steve_Eule__Climate_Change_Scale_and_Scope_of_the_Challenge.aspx

most energy-starved continent on the planet. Understandably, China, India, and other developing countries reject binding limits on their emissions. The question, then, is what kinds of inducements would be required to make them join the club of the carbon-constrained.

One option is bribery[49] — huge transfers of wealth and technology from North America, Europe, and Japan. But in case anyone hasn't noticed, the world is in a financial crisis, and unemployment is high in the United States and other industrial countries. U.S. taxpayers would take a dim view of subsidizing Chinese industry in order to send yet more jobs to China. Besides, although China and India would be only too happy to take our money, they have not indicated that they would return the favor by capping their emissions.

If carrots won't work, then sticks — such as the carbon tariffs recently demanded by 10 U.S. Senators[50] and French President Sarkozy[51] – would appear to be the only option to make developing countries comply. If we go down that path, however, we will continually butt heads with China, India, and other important trade partners. China has already threatened to retaliate against carbon tariffs with trade sanctions of its own. In all likelihood we would get trade war, not compliance.[52]

Trade wars do not usually lead to shooting wars, but an era of trade conflict with China would not be in the U.S. national interest, and disaster scenarios are easily imagined, as my colleague Iain Murray points out.[53] Example: A Chinese firm refuses to pay the carbon tariff. U.S. port authorities refuse to allow the goods to be off-loaded, the Chinese sailors get rowdy, the police come, they injure a sailor — bingo, international incident.

More prosaically, China could simply become less amenable (or more obstructionist) in areas where we seek their cooperation, such as sharing intelligence on terrorist activities[54] and restraining North Korea[55] and Iran's nuclear ambitions.[56]

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[48] See the *International Energy Annual 2006*, released by the Energy Information Administration on December 8, 2008: http://www.eia.doe.gov/pub/international/iealf/tableh1cco2.xls

[49] Björn Lomborg, "We need to invest in green technologies, not bribery," guardian.co.uk, 135 February 2009. http://www.lomborg.com/dyn/files/news_news/106-file/BL%20op-ed%20Febr%2015%202009%20China%20and%20India.pdf

[50] Keith Johnson, "Cap and Trade: Ten Democratic Senators Call for Carbon Tariffs," *The Wall Street Journal*, August 6, 2009. http://blogs.wsj.com/environmentalcapital/2009/08/06/cap-and-trade-ten-democratic-senators-call-for-carbon-tariffs/

[51] Peggy Hollinger, "Sarkozy calls for carbon tax on imports," *Financial* Times, September 10, 2009. http://www.ft.com/cms/s/a5fb6084-9e32-11de-b0aa-00144feabdc0,Authorised=false.html?_i_location=http%3A%2F%2Fwww.ft.com%2Fcms%2Fs%2F0%2Fa5fb6084-9e32-11de-b0aa-00144feabdc0.html%3Fnclick_check%3D1&_i_referer=&nclick_check=1

[52] People's Daily Online, "China: carbon tariff could trigger trade war," July 3, 2009: http://english.peopledaily.com.cn/90001/90778/90857/90861/6693060.html

[53] http://corner.nationalreview.com/post/?q=MzhmYWY5OWZmNDRjMGUzY2JlYTZkMzgyMGZkZDMzMjM=

[54] Shirley A. Kan, "U.S.-China Counterterrorism Cooperation: Issues for US Policy," August 3, 2009. http://www.fas.org/sgp/crs/terror/RL33001.pdf

[55] "China and Proliferation of WMD and Missiles," *Defense Talk*, August 12, 2009. http://www.defencetalk.com/china-and-proliferation-of-wmd-and-missiles-21090/

(5) Nuclear proliferation. At the PSA panel, Ambassador James Woolsey argued against sharing nuclear technology with developing countries, even though nuclear power is the world's leading source of zero-emission electricity. This would create a "huge proliferation problem"; nuclear must take "big steps" before it is a "reasonable competitor to other options," he said.

However, if developing countries are denied access to coal-fired power plants, where else are they going to get substantial base load electricity, if not from nuclear power? It is difficult to imagine developing countries consenting to a moratorium on coal power plants unless industrial countries agree to share nuclear technology with them, and pay for it to boot.

Nothing would spread nuclear technology and fissile materials faster than an effectively enforced ban on new coal power plants, especially if the G77 plus China get their wish and industrial countries pony up 0.5%-1% of their GDP annually in international "climate assistance."[57]

At a minimum, cap-and-traders should acknowledge that increased proliferation risk is a potential consequence of the global warming crusade.

(6) Europe's dependence on Russian gas. "Clean energy" advocates decry America's dependence on oil from unfriendly nations, and say we must transition away from oil to win the war on terror.

At the same PSA briefing, Ambassador Woolsey asked the audience, "Who funds terror?" Answering his own question, he said: "Look in the mirror the next time you fill up at the gas station." A clever sound bite, if the point is to evoke and manipulate feelings of guilt. You get the same look-in-the-mirror answer when you ask, "Who finances 28 million retirement accounts in 2,650 federal, state, and local public employee pension funds?"[58]

Woolsey overstates the link between oil and terror, as Jerry Taylor and Peter Van Doren of the Cato Institute explain:[59]

- Although some of the dollars we spend on oil undoubtedly trickle into terrorist coffers, "only 15.5 percent of the oil in world markets is produced in nation-states accused of funding terrorism." Presumably, those states fork over only a small fraction of their oil revenues to terrorists. "Hence, the vast majority of the dollars we spend do not end up on the purported conveyor belt to terrorist bank accounts."

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[56] Jamie Glazov, "The China-Russia-Iran Axis," Frontpagemagazine.com, January 22, 2008. http://www.frontpagemag.com/readArticle.aspx?ARTID=29604

[57] The proposal of China and the G77 for "climate assistance" can be viewed at: http://unfccc.int/files/kyoto_protocol/application/pdf/g77_china_financing_1.pdf

[58] Robert J. Shapiro and Nam D. Pham, "The Economic Impact of a Windfall Profit Tax on Federal, State, and Local Public Employee Pension Funds," February 2006. http://www.sonecon.com/docs/studies/wpt_0206.pdf

[59] Jerry Taylor and Peter Van Doren, "The Energy Security Obsession," *The Georgetown Journal of Law and Public Policy*, Summer 2008, Vol. 6, No. 2. http://www.cato.org/pubs/articles/energy-security.pdf

- "Regardless, terror is a low-cost endeavor and oil revenues are unnecessary for terrorist activity. The fact that a few hundred thousand dollars paid for the 9/11 attacks suggest that the limiting factor for terrorism is expertise and manpower, not money."
- Analyzing data on oil prices and terrorist incidents from 1983 to 2005, Taylor and Van Doren found no correlation between Saudi oil profits and fatalities due to Islamic terrorist attacks, and none between Saudi oil profits and the number of Islamic terrorist incidents.

As to the concern about depending on oil from unfriendly countries, Taylor and Van Doren note that the OPEC "oil weapon" (embargoes, cutoffs) is mostly bluster. Petro states go broke if they don't sell oil, and, because oil markets are global, an embargoed nation can always import oil via non-embargoed third parties.

An energy extortion strategy is more feasible with natural gas. As Taylor and Van Doren explain, "sellers have leverage in natural gas markets that is not possible in oil markets because oil can be transported easily while gas is shipped through pipelines. Buyers have few near-term alternatives if natural gas sellers reduce shipments."

Due to the geographically-constrained character of natural gas markets, Europe, which imports about 40% of its natural gas from Russia, is far more vulnerable to energy extortion than we are.

Table 2: Major Recipients of Russian Natural Gas Exports, 2005

Rank	Country	Imports (bcf/y)	Percent of Domestic NG Consumption
1	Germany	1,291	36%
2	Italy	824	27%
3	Turkey	630	65%
4	France	406	23%
5	Hungary	294	56%
6	Czech Republic	252	75%
7	Austria	246	72%
8	Poland	226	39%
9	Slovakia	226	99%
10	Finland	148	95%
11	Romania	140	22%
12	Fmr Yugoslavia	134	57%
13	Bulgaria	101	53%
14	Greece	85	85%
15	Switzerland	13	11%
Sales to Baltic & CIS States, 2005			
	Ukraine	2,113	69%
	Belarus	710	99%
	Baltic States	205	89%
	Azerbaijan	120	33%
	Georgia	46	88%

Sources: Domestic Consumption: EIA International Energy Annual, 2005; Imports: Cedigaz 2006 and BP Statistical Review 2007.

Ten months ago, in the midst of a very cold winter, Russia halted gas exports to Ukraine, thereby cutting off nearly all gas shipments to Europe.[60] Although Russia claimed it was simply trying to resolve a longstanding dispute with Ukraine over gas prices and debts, the cutoff may also have been punishment for Ukraine's pursuit of NATO membership, and a warning to Europe not to admit Ukraine into NATO.[61]

Europe's dependence on Russian gas partly stems from EU global warming policy. The U.S. Energy Information Administration (EIA) observes: "Many nations in OECD Europe have made commitments to reduce carbon dioxide emissions, bolstering the incentive for governments to encourage natural gas use in place of other fossil fuels."[62]

If Europe's deeds ever match its green rhetoric, and European countries ban new coal plants instead of building them,[63] they will become even more dependent on Moscow to keep their lights on and their houses warm.

Although Soviet communism is dead, Russia is not a liberal democracy. Moscow aspires to regain Russia's great power status, and whatever else might be said about Russia, its interests in Europe are not identical to ours. Last year, for example, a Russian general threatened to nuke Poland, if Warsaw participates in a U.S. missile defense system designed to block attacks by rogue nations like Iran.[64]

In short, the Russian Bear is not yet tame, Europe's dependence on Russian natural gas makes Europe vulnerable to energy extortion, and regulatory climate policies increase that vulnerability. Enacting Kerry-Boxer would only encourage Europe to remain on the potential dangerous energy path it has chosen.

Finally, even on the assumption that oil imports are a menace, cap-and-trade would likely increase our dependence on imported petroleum products by reducing investment in the U.S. petroleum refining sector. A report[65] prepared by EnSys Energy for the American Petroleum Institute, finds that by 2030, Waxman-Markey would:

- Significantly increase U.S. refining costs;
- Reduce U.S. refining volume by up to 4.4 million barrels per day (mbd);
- Reduce annual U.S. refining investments by up to $89.7 billion (up to an 88% decline in investment);
- Reduce refinery utilization rates from 83.3% to as low as 63.4%;

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[60] Andrew E. Kramer, "Russia Cuts Gas, and Europe Shivers," *The New York Times*, January 6, 2009. http://www.nytimes.com/2009/01/07/world/europe/07gazprom.html

[61] Tom Lasseter, "10 countries cut off as Russia-Ukraine gas dispute spreads," McClatchy Newspapers, January 6, 2009. http://www.mcclatchydc.com/world/story/59099.html

[62] See chapter 3 of the International Energy Outlook 2009, released on 27 May, 2009 by the Energy Information Administrqation. http://www.eia.doe.gov/oiaf/ieo/nat_gas.html

[63] Elisabeth Rosenthal, "Europe Turns Back to Coal, Raising Climate Fears," *The New York Times*, April 23, 2008. http://www.nytimes.com/2008/04/23/world/europe/23coal.html

[64] "Q&A: US Missile Defence," *BBC News*, September 20, 2009. http://news.bbc.co.uk/2/hi/europe/6720153.stm

[65] Ensys Energy, Waxman-Markey (H.R. 2454) Refining Sector Impact Assessment, August 21, 2009, http://www.api.org/Newsroom/upload/ENSYS_W_M_Briefing_Report_2009_8_20.pdf

- Create competitive advantage for non-U.S. refineries; and, hence
- Increase U.S. reliance on petroleum product imports.

(7) Biofueling Disaster. Increased use of biofuels will help break America's oil dependence, Ambassador Woolsey asserted. Well, no, it won't, unless biofuels actually give consumers more bang for the buck than gasoline does — in which case there will be no need for the biofuel and flex-fuel mandates Woosley advocates.

For all their fretting about how climate change will undermine U.S. security by intensifying world hunger, the PSA panelists uttered not a word about the role of biofuel policiès in increasing grain prices and world hunger.

The price of corn tripled during 2007-2008, and wheat and rice prices also more than doubled. I don't usually quote eco-radical George Monbiot, but on this topic nobody said it better: "even when the price of food was low, 850 million people went hungry because they could not afford to buy it. With every increment in the price of flour or grain, several million more are pushed below the bread line."[66] In 2008, food riots sparked by soaring grain prices broke out in several countries and toppled the government in Haiti — the very sort of instability we're supposed to fear from climate change, but climate change had nothing to do with it.[67]

Although several factors contributed to the surge in grain prices including a weak dollar, high oil prices, and increased demand in China and India, biofuel policies were also a factor. According to the World Bank, "Almost all the increase in global maize [corn] production during 2004 to 2007 (the period when grain prices rose sharply) went to bio-fuels production in the United States, while existing stocks were depleted by an increase in global consumption for other uses."[68] The numbers tell the story: "From 2004 to 2007, global maize production increased by 51 million tons, biofuel use in the United States increased 50 million tons and global consumption for all other uses increased 33 million tons, which caused global stocks to decrease by 30 million tons."

Biofuel policy bid up the price of corn and, since all grains compete for customers and, to a lesser extent, land, biofuel policy contributed to grain price inflation generally. The International Food Policy Research Institute estimates that during 2000 to 2007, biofuel demand accounted for 39% of the increase in real corn prices, 22% of the rise in wheat prices, and 21% of the increase in rice prices.[69] A study published by the World Bank (although not representing the Bank's official position) estimates that 70-75% of the increase in food commodity prices "was due to

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[66] George Monbiot, An Agricultural Crime Against Humanity, Feb. 6, 2007, http://www.monbiot.com/archives/2007/11/06/an-agricultural-crime-against-humanity/

[67] "Riots, instability spread as food prices skyrocket," CNN, April 14, 2008. http://www.cnn.com/2008/WORLD/americas/04/14/world.food.crisis/

[68] *Rising Food Prices: Policy Options and World Bank* response, World Bank, February 2009. http://siteresources.worldbank.org/NEWS/Resources/Developmentcommittee_note_Apr11.doc

[69] Joachim von Braun, *Biofuels, International Food Prices, and the Poor*, International Food Policy Research Institute (IFPRI), 2008. http://energy.senate.gov/public/_files/vonBraunTestimony061208.pdf

biofuels and the related consequences of low grain stocks, large land use shifts, speculative activity and export bans."[70]

Technological breakthroughs may some day make it possible to produce vast quantities of cheap ethanol from switch grass or algae. In the meantime (which could be decades), the potential of biofuel mandates to divert ever-increasing quantities of grain from food to auto fuel, inflate food prices, and increase world hunger cannot reasonably be denied.

Now, consider these risks in the context of the EU/UN/Al Gore goal of reducing CO2 emissions to 50% below current levels by 2050. Achieving that goal would require global emissions in 2050 to be 38.3 billion tons below the baseline projection, estimates Stephen Eule of the U.S. Chamber of Commerce's Institute for 21st Century Energy.[71]

Achieving just one gigaton or 2.6% of that reduction from biofuels would require biomass plantations occupying an area about 5.4 times the total land area of Iowa – about 200 million acres, Eule estimates.

Our supposed ability to "solve the climate crisis" just by scaling up off-the-shelf technologies is often discussed in terms of "stabilization wedges," a concept popularized by Princeton researchers Steven Pacala and Robert Socolow. In a widely cited paper, Pacala and Socolow outline 15 policy options (wedges) each of which could lower global emissions by 1 gigaton in 2050 or by 25 gigatons from 2004 to 2054.[72]

One of the options is to produce 34 million barrels of ethanol a day – "about 50 times larger than today's [2004's] production rate, almost all of which can be attributed to Brazilian sugar cane and United States corn." The ethanol wedge, they estimate, would require 250 million hectares of high-yield plantations by 2054, "an area equal to about one-sixth of the world's current cropland." *One-sixth of the world's current crop land!*

It doesn't take military intelligence to see that "saving the planet" with biofuels could significantly reduce the land area available for food crop production. The world is not well fed now, and the food and feed demands on farmlands are expected to more than double by 2050.[73] The potential for disaster is obvious.

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[70] Donald Mitchell, *A Note on Rising Food Prices*, The World Bank Development Prospects Group, July 2008. http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2008/07/28/000020439_20080728103002/Rendered/PDF/WP4682.pdf

[71] Stephen E. Eule, *Climate Change: Scale & Scope of the Challenge to Reduce Global Greenhouse Gas Emissions*, February 2009. http://www.energyxxi.org/images/Uploaded/ClimateScale_ScopePresentation2-2009.pdf

[72] S. Pacala and R. Socolow, "Review: *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*," *Science*, 13 August 2004, Vol. 305. http://carbonsequestration.us/Papers-presentations/htm/Pacala-Socolow-ScienceMag-Aug2004.pdf

[73] Dennis Avery, *Biofuels, Food, or Wildlife? The Massive Costs of U.S. Ethanol*, CEI Issues Analyis, September 21, 2006. http://cei.org/pdf/5532.pdf

Conclusion

The climate debate suffers from a stupendous lack of balance. The risks of climate change are trumpeted, magnified, and in some cases even invented. The risks of climate change policies are discounted, denied, and, more frequently, ignored. Yet climate change policies have an enormous potential to damage U.S. national security, international stability, and the security of the world's poorest nations. Members of the Committee should ponder these risks before deciding their position on the Kerry-Boxer bill.