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S. 1008—THE CLIMATE CHANGE STRATEGY AND TECHNOLOGY INNOVATION ACT OF 2001

HEARING

BEFORE THE

COMMITTEE ON GOVERNMENTAL AFFAIRS UNITED STATES SENATE

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

ON

S. 1008

TO AMEND THE ENERGY POLICY ACT OF 1992 TO DEVELOP THE UNITED STATES CLIMATE CHANGE RESPONSE STRATEGY WITH THE GOAL OF STABILIZATION OF GREENHOUSE GAS CONCENTRATIONS IN THE ATMOSPHERE AT A LEVEL THAT WOULD PREVENT DANGEROUS ANTHROPOGENIC INTERFERENCE WITH THE CLIMATE SYSTEM, WHILE MINIMIZING ADVERSE SHORT-TERM AND LONG-TERM ECONOMIC AND SOCIAL IMPACTS, ALIGNING THE STRATEGY WITH UNITED STATES ENERGY POLICY, AND PROMOTING A SOUND NATIONAL ENVIRONMENTAL POLICY, TO ESTABLISH A RESEARCH AND DEVELOPMENT PROGRAM THAT FOCUSES ON BOLD TECHNOLOGICAL BREAKTHROUGHS THAT MAKE SIGNIFICANT PROGRESS TOWARD THE GOAL OF STABILIZATION OF GREENHOUSES GAS CONCENTRATIONS, TO ESTABLISH THE NATIONAL OFFICE OF CLIMATE CHANGE RESPONSE WITHIN THE EXECUTIVE OFFICE OF THE PRESIDENT, AND FOR OTHER PURPOSES

JULY 18, 2001

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S. 1008—THE CLIMATE CHANGE STRATEGY AND TECHNOLOGY INNOVATION ACT OF 2001

WEDNESDAY, JULY 18, 2001

U.S. SENATE,
COMMITTEE ON GOVERNMENTAL AFFAIRS,
Washington, DC.

The Committee met, pursuant to notice, at 9:30 a.m., in room SD–342, Dirksen Senate Office Building, Hon. Joseph Lieberman, Chairman of the Committee, presiding.

Present: Senators Lieberman, Thompson, Stevens, Voinovich, Collins, and Bennett.

OPENING STATEMENT OF CHAIRMAN LIEBERMAN

Chairman LIEBERMAN. The hearing will come to order. I welcome our witnesses and our guests this morning. I would like to thank them for joining us to present testimony regarding the Climate Change Strategy and Technology Innovation Act of 2001, which has been introduced by our colleagues, Senators Byrd and Stevens. In the long term, I think there is no greater environmental challenge facing the United States and the world than global climate change. It is also a most complicated international matter, to devise an appropriate response.

Two recent scientific reports, one by the United Nations and the second by the National Academy of Sciences, confirmed some of the worst fears about climate change. These reports conclude that the Earth is warming; that the warming is caused by human activities; and that, unless we reverse this trend, we will face dire consequences, including rising sea levels, widespread drought, the spread of diseases associated with warmer weather, and an increase in extreme weather events.

Most everyone agrees that there is a problem and on the need for a strong response, except frankly some here in the United States. One need only look to Genoa and Bonn, where thousands of protesters are gathering to demonstrate against President Bush's decision to walk away from the Kyoto Protocol, to appreciate the depth of conviction associated with this problem of global warming and the extent to which the United States has now separated itself from most of the rest of the world on this subject.

Personally, I feel that we need an international agreement with binding targets and timetables for reducing greenhouse gas emissions. I say that because in the aftermath of the Rio Treaty, which the Senate ratified on October 15, 1992, which set out a series of targets and timetables that were meant to be voluntarily complied

with, but were not, that the answer, I believe, is that we need binding targets and timetables.

I know that some of my colleagues feel otherwise, but the truth is that we are not here today to debate those questions, although I would guess that we will hear some of the differing points of view on them. That is because our two colleagues, Senators Byrd and Stevens, have, I think, put together a legislative proposal that creates common ground that all of us can occupy and from which we can move forward together. Achieving a bipartisan consensus on this legislation can, I believe, be an historic turning point in the United States' response to global climate change.

The legislation Senators Byrd and Stevens propose will create a focused, comprehensive effort within the Executive Branch that will provide the leadership and creative work that the problem of global warming requires. The bill will establish a new National Office of Climate Change Response in the White House, comparable in some ways to the current Office of National Drug Control Policy, to develop a peer-reviewed strategy to stabilize the levels of greenhouse gases in our atmosphere, in order to prevent dangerous disruption of the climate system.

That is a goal that we have all agreed to in the aforementioned Rio Treaty on climate change, which again the Senate ratified in October 1992. This bill will also create the infrastructure needed to develop the innovative technologies that will be necessary to address global warming and it will authorize funding for those efforts. With this bill, research and development activities on greenhouse gas mitigation would have a home centered in the Department of Energy from which they could be aggressively pursued, and in crafting a climate change strategy, the office within the White House would be instructed by this proposal to consider four key elements: Emissions mitigation; technology development; adaptation needs; and further scientific research.

As Senator Byrd has said, this bill is meant to complement, not replace, other greenhouse gas mitigation measures by creating a process by which we receive expert evaluation of the challenge we face and fund research work to meet it. This legislation, I think, will become the tree from which other climate change measures will branch. In the end, I believe our shared responsibility is clear. We have got to take action and take it soon to deal with this problem that will affect our children and grandchildren and theirs, more than it will directly affect us.

I would close by saying that in their long and distinguished careers in the Senate, Senators Robert C. Byrd and Ted Stevens have not only made history, they have shown they understand history and the responsibility for leadership that history places on those of us who are privileged to serve here. In this bipartisan breakthrough proposal on global climate change, they have once again shown the rest of us a way to move forward together. For that, I thank them.

Senator Thompson.

OPENING STATEMENT OF SENATOR THOMPSON

Senator THOMPSON. Thank you, Mr. Chairman, for holding this hearing on legislation pending before the Committee on the impor-

tant issue of climate change. The risk from human-induced climate change is a risk that we should responsibly try to manage. When contrasted against the Kyoto protocol, S. 1008 offers a potential for a reasonable way forward, I believe. S. 1008 would require the development of a national climate change strategy and authorize new funding for the development of breakthrough energies technology needed to reduce the risk of climate change.[1]

We are going to need these technologies if we want to meet the objective of the U.N. Framework Convention on Climate Change, which the United States has ratified. The objective was the long-term stabilization of atmospheric greenhouse gas concentrations in the future, and to meet this, we are going to have to develop fundamentally new ways of producing and using energy that give us the energy we need without the emissions that we do not want.

But reducing CO_2 emissions is not as simple as putting a scrubber on a smokestack. We are going to need new technologies, and we must seek a global solution, one that involves all nations of the world and not just the developed ones. These are some of the reasons why I applaud the President's rejection of the Kyoto Protocol. I also support the President's effort to define the new way forward, both domestically and internationally.

The flawed Kyoto Protocol would place unfair, expensive limits on the United States. It could have rationed the amount of energy the United States could have used, even though energy is key to American prosperity. It could have caused significantly higher energy costs. It could have significantly reduced the rate of economic growth, affecting millions of jobs, eliminating the surplus and threatening American global competitiveness. Some of our biggest economic rivals would be exempt from the emission limits.

It appears that a new approach to managing the risk of climate change is needed, and the President is providing it. The President's plan will focus on managing the risk of climate change using American technology, ingenuity and innovation. It will involve quantifying and understanding the risk of climate change through improved climate observations and models. It will involve developing the tools we will need to reduce the future risk of climate change, advanced energy technologies. Such useful concepts are reflected in S. 1008. I also understand that several of my colleagues, including Senators Murkowski, Craig and Hagel, may soon introduce legislation that could make positive additions to S. 1008. There is a great deal of controversy surrounding the politics and science of global climate change. While I am concerned about spending such large sums of money in creating new bureaucracies, there may be broad support for the notion that we will need significant investment in R&D to be prepared to address the challenge of climate change.

There is significant disagreement on other policy options, like mandatory caps on emissions, and as the National Academy recently pointed out, there are still significant uncertainties in our scientific understanding of climate change. But perhaps we can start by reducing the gaps in our scientific understanding to quantify the risk we face, and we can develop the energy technology

[1] Copy of S. 1008 appears in the Appendix on page 144.

tools we are going to need if we want to act dramatically to reduce the risk of future climate change.

I look forward to hearing from our distinguished witnesses.

Chairman LIEBERMAN. Thanks very much, Senator Thompson. We have been following a procedure here where we have opening statements just from the Chair and the Ranking Member, so I am going to ask Senator Byrd to testify now. But then obviously, because Senator Stevens is a co-sponsor, I will ask him, if he wishes, after you conclude, to speak.

Senator Byrd, we are honored to have you here and look forward to your testimony.

TESTIMONY OF HON. ROBERT C. BYRD, A U.S. SENATOR FROM THE STATE OF WEST VIRGINIA

Senator BYRD. Thank you, Mr. Chairman, Senator Thompson, Senator Stevens, Senator Voinovich, Senator Collins, other Members of the Committee. I thank you very much for inviting me to speak on behalf of S. 1008, the Climate Change Strategy and Technology Innovation Act of 2001. I thank you for holding this hearing on legislation that Senator Stevens and I have introduced and which we believe incorporates the interests of a wide range of members on both sides of the aisle.

I have spoken twice in recent months on the Senate floor about the issue of global climate change. My desire to discuss this important issue derives not only from my sense of personal concern, but also from my optimistic belief that we can meet the climate change challenge if we are willing to make a commitment to do so. It is my position that all nations, industrialized and developing countries alike, must begin to honestly address the multifaceted and very complex global climate change problem.

At the same time, I believe that our Nation is particularly well-positioned with the talent, the wisdom, the drive, in leading efforts to address the problem that is before us. It is for these reasons that my friend, Senator Stevens, and I introduced the legislation that is under consideration before this Committee today. The Byrd-Stevens climate change action plan recognizes the awesome problem posed by climate change. It puts into place a comprehensive framework, as well as a research and development effort to guide U.S. efforts far into the future.

This legislation authorizes a major new infusion of funding for the research and development efforts to help create and deploy the next generation of innovative technologies that will be needed to address the climate change challenge in the coming decades. S. 1008 establishes a regime of responsibility and accountability in the Federal sector for the development of a national climate change response strategy.

That strategy, Mr. Chairman, calls for a new framework to deal with a comprehensive climate change approach. To implement this strategy, this legislation provides for the creation of an administrative structure within the Federal Government, including an office in the White House to coordinate and implement this strategy. S. 1008 also creates a new office in the Department of Energy that will work on long-term research and development of a type that is

not currently pursued in more conventional research and development programs today.

The bill creates an independent review board that will report to Congress to ensure that these goals are achieved. Under S. 1008, we can begin to take action on climate change through a comprehensive and aggressive approach. It is a bipartisan initiative that is intended to supplement, rather than replace, other complementary proposals to deal with climate change. This bill is technology-neutral and does not carve out special benefits for any one energy resource or technology.

We must put a portfolio of options on the table if we are to have any hope of solving this dilemma. This legislation provides for the broad framework necessary to address the climate change challenge. It reaffirms the goal of stabilizing atmospheric greenhouse gas concentration. It leaves the technology decisions to energy experts and the marketplace, and it recognizes the vital need to support public-private partnerships in developing these technologies.

Senators we have an opportunity before us that we should not let slip away. It is not just an opportunity. It is also a very heavy responsibility. As this Senate begins to address our Nation's many energy and environmental concerns, climate change legislation must be part of that equation, and the Byrd-Stevens climate change action plan can help to chart that course. Addressing global climate change takes clear-headed and strong leadership. It requires extraordinary leadership.

While our current menu of climate change policies and programs is an important first step, this approach only pays lip service to the awesome challenge that we face. We must go further than just making small incremental improvements in our existing research and development programs. It is a huge challenge. I hope that this Congress and this administration are willing to step up to the plate. Rarely has mankind been confronted with such an undertaking, the need to improve the energy systems that power our economy

This is the greatest Nation in the world when the issue is one of applying our talents to push beyond the next step, and instead to visualize, conceptualize and then to achieve major leaps forward. We have put a man on the Moon and brought him back to Earth. We have helped to eradicate insidious diseases that have ravaged the peoples of the Earth. Our Nation is a world leader in medical and telecommunications technologies. We should also be a leader when it comes to revolutionizing our energy technologies. Such a commitment would be important for our economy, our energy security, and the global environment overall.

But I must ask how long are we going to wait to develop these technologies? This is a huge opportunity for our Nation, but our efforts will only be rewarded if we can make a concerted commitment and dedicate ourselves to the task ahead, and that will not be easy. Make no mistake about it, global climate change is a reality. There are some who may have misinterpreted my stance on this issue, based on S. Res. 98 of July 1997, which I co-authored with Senator Hagel. That resolution, which was approved by a 95–0 vote, said that the Senate should not give its consent to any future binding

international climate change treaty which failed to include two important provisions.

That resolution simply stated that developing nations, especially those largest emitters, must also be included in any treaty and that such a treaty must not result in serious harm to the U.S. economy. In other words, we needed to proceed with our eyes open and we asked the administration—the then-administration—to provide to the Congress the estimates of cost of the treaty, cost to the various industries in this country, the automobile industry, the mining industry and so on. Those estimates have not yet been provided.

I still believe that these two provisions are vitally important components of any future climate change treaty, but I do not believe that this resolution should be used as an excuse for the United States to abandon its shared responsibility to help find a solution to the global climate change dilemma. At the same time, we should not back away from efforts to bring other nations along. The United States will never be successful in addressing climate change alone.

We are all in the same boat, and what comes around goes around. The pollution that begins with China and Indonesia and Mexico, Brazil, and other developing countries, comes around to the United States and to Great Britain and to the European countries. It is a global problem that requires a global solution. It is critical that nations such as those I have mentioned, China, India, Mexico, Brazil and other developing nations, adopt a cleaner, more substantial development path that promotes economic growth while also reducing their pollution and greenhouse gas emissions.

In the Senate's fiscal year 2001 energy and water appropriations bill, I inserted language that created an interagency task force to promote the department of U.S. clean-energy technologies abroad. Such an initiative is complementary to the efforts proposed in S. 1008. The clean-energy technology exports initiative is now underway and will help foreign nations to deploy a range of clean-energy technologies that have been developed in our laboratories.

These technologies are hugely marketable. Many of them have resulted from our clean-coal technology, which I initiated in 1985, with $750 million committed to the task. It has been an immensely successful program. The private sector has come forward with more than it was required. It was required to come forward with 50 percent of the cost. It has put two-thirds of the cost on the barrelhead and several technologies have gone forward and proved to be successful

If nations like China continue to depend on coal and other fossil fuels to grow their economies into the future, it is incumbent upon the United States to accelerate the development, demonstration and deployment of clean coal and other clean-energy technologies that will be critical to meeting all nations' energy needs, while also providing for a cleaner environment. I believe that S. 1008 maps a responsible and realistic course. That road may be bumpy and I am sure that there will be disagreements along the way, but it is a journey that we have to take. We owe it to future generations.

S. 1008, if adopted and signed by the President, will commit the United States to a serious undertaking, but one that should no longer be ignored. If we are to have any hope of solving one of the

world's and one of humanity's greatest challenges, we must begin now. Mr. Chairman, I again thank you for holding this hearing. I again thank my colleague, Senator Stevens, for his vision, his leadership, for his cooperation, for his joining in the promotion of this legislation. I look forward to working with you, Senator Lieberman, and with you, Senator Thompson, Senator Stevens and the other Members of this Committee on this important and timely legislation. It is not a moment too soon.

I ask unanimous consent that my May 4, 2001 and June 8, 2001 climate change statements printed in the Congressional Record be made a part of the record.[1]

Chairman LIEBERMAN. Without objection.

Senator BYRD. That completes my statement, Mr. Chairman.

Chairman LIEBERMAN. Thank you very much, Senator Byrd, for a very thoughtful, very important statement, and one that has, I think, the appropriate sense of urgency.

Senator Stevens.

OPENING STATEMENT OF SENATOR STEVENS

Senator STEVENS. Well, thank you very much, Mr. Chairman, and I, too, join Senator Byrd in thanking you for holding this hearing, and I commend my good friend from West Virginia for his leadership in trying to establish a major research effort to reduce carbon emissions and deal with the whole subject, the myriad of subjects that are included in global climate change strategy. I thank you very much, Senator Byrd, for allowing me to join you on this, because it is a matter of great importance to me and my State, as you know.

I think, Mr. Chairman, Senator Thompson, Members of the Committee, in days gone by, Senator Byrd and I might have just added this to an appropriations bill.

Chairman LIEBERMAN. We still were hoping that eventually you might do that. [Laughter.]

Senator STEVENS. The difference is that we know this is such a complex subject, one that needs congressional approval before we forge into this area. We want to make sure that you are all behind us before we try to put the taxpayers' money where our mouths have been. We need funds for this. I view this as being next to major medical research in terms of issues that this country faces, and I want to tell you I am particularly interested because of the last hearing I chaired, Mr. Chairman, as Chairman of the Appropriations Committee, was a field hearing in Fairbanks on the impacts of global climate change on the Arctic environment.

I would welcome and urge you to think about bringing the whole Committee up to see what global climate change means. There is no question that the change has taken place more rapidly in the Arctic than anywhere else on the globe. Many of the witnesses at our hearing noted that climate activity stems from a number of factors, including human activity. I do not think we can assess it totally to human activity.

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[1] The statements submitted by Senator Byrd from the Congressional Record on May 4, 2001 and June 8, 2001 appear in the Appendix on pages 112 and 114 respectively.

The degree to which any particular phenomenon or activity contributes to climate change is not yet well-understood. Regardless of the cause, there has been a dramatic warming trend in the Arctic areas, as I said. Let me tell you, pack ice, which is the ice that insulates our coastal villages from winter storms, has shrunk 3 percent per year since 1970. Increased storm activity has caused significant beach erosion, which now has required us to consider ways to displace entire communities along the coastline of Alaska.

The sea ice is thinner than it was 30 years ago, and the sea ice is the platform on which most of the reproductive activity of marine mammals takes place. It is back from the shore now. This is permanent ice that is thinning. As a matter of fact, I was told it was three inches thinner this year than last year. The Northwest Passage has been opened now for 3 years. I remember so well, as a young Senator, when I went on the MANHATTAN and tried to accompany many people and see if we could use the Northwest Passage to transport Alaska's oil to the East Coast, rather than build a pipeline; and it failed, as you know, because of the ice.

We spent days riding that ice breaker tanker, grinding three, four, five miles a day of ice. That is gone now. It is not there. The Northwest Passage is just one of the indications. I would invite you to come up and see our northern forests. Our northern forests are now farther north and further west, as the permafrost is melting, and the permafrost melting means a great deal to us. Half of the coal in the United States is in that area, of the permafrost of Alaska. Whether we will ever be required to use it, I do not know, but under current law, we would have to replace the contour of the land if we took the coal out. Of course, that is an impossibility.

Now, the powers-that-be, the Good Lord, is melting that permafrost and the contour may not be the same in future years as it is now. It might be easier to get to the coal. But this legislation provides us a balanced approach to climate change and will help us deal with the issue of greenhouse gases and do so without harming the economy of the United States, and to increase the capability of Third World countries to improve their economy. By making necessary research and development efforts now, I think we can inspire a generation of technologies that will enhance America's chance to be the leader in dealing with global climate change.

It will increase research and development funding, so we can better understand this global climate change. We can plan to develop the capabilities that technology will lead us to, and I think we will be able to react to global climate change in a very positive way if we follow the Senator's lead, and I am glad to be his partner in this effort. This bill will require, in my judgment, that we double the technology investment for research and development related to global climate change, just as we doubled the investment in health research in the last 5 years. This will lead us into a new era of funding for research in this area.

I think there should be no misunderstanding about it, because I have joined Senator Byrd in making a commitment that this money will be made available to the research community, so we can better understand these changes and take whatever actions we can to offset them. It will create a process for the United States to take seriously this issue and to address it promptly. I thank you for holding

the hearing, and again I repeat my invitation to you to come up and see what is happening. I was told in Fairbanks that while the world as a whole may have increased in temperature by about one degree, the Arctic has increased in temperature by seven degrees, and we took our committee to Antarctica to see if the same situation was developing down there.

They have increased ice pack down there. They have increased problems down there, but they are not as much involved in global climate change as we are in the Arctic. The Arctic is the place to understand global climate change and I am proud, Senator, that you allowed me to join you in this effort, and pledge that we will fight this battle together. We need this information. We need to develop this technology as rapidly as possible.

Thank you very much.

Senator BYRD. Thank you, Mr. Chairman.

Chairman LIEBERMAN. Senator Stevens, thank you very much for that very compelling testimony, and particularly for the memorable reports from Alaska and the Arctic. I accept your invitation. I think Senator Thompson and I ought to figure out a way to see if we can bring the Committee exactly to the places you described. In a way, it may be that Alaska and the Arctic are the early warning system or, to use an old and worn expression, the canary in the coal mine, in the case of climate change. I thank you.

Senator Byrd, thank you very much for your time. I know you have a busy schedule and I appreciate very much your being here today.

Senator STEVENS. Please excuse me, too. I have another——

Chairman LIEBERMAN. Oh, you have a busy schedule, too. It is always great, not only to have your leadership on a critical problem like this, but to know when we have your leadership, the prospects of funding such a bill are quite high. [Laughter.]

Thank you. We will call the second panel: Dr. James Hansen, Head of NASA Goddard Institute for Space Studies; and Thomas Karl, Director of the National Climatic Data Center. Dr. Hansen, why don't you proceed? We have a clock going. Your full statement, which we appreciate, will be printed in the record in full, and I ask you to try to stay pretty much as close to the 5 minutes as you can. Then it is the tradition of the Committee now to give each Senator 10 minutes. So if any of my colleagues want to make opening statements, that hopefully will give them the opportunity to do that, as well.

Dr. Hansen.

TESTIMONY OF JAMES E. HANSEN,[1] Ph.D., HEAD, NASA GODDARD INSTITUTE FOR SPACE STUDIES

Mr. HANSEN. Thank you, Senator Lieberman. I will talk about options for influencing future climate. The most popular prediction for future climate change is based on the business-as-usual scenario, in which the annual increments of the forcing agents that drive climate change grow larger and larger every year. This sce-

[1] The prepared statement of Mr. Hansen with attachments appears in the Appendix on page 51.

nario leads to a prediction of dramatic climate change, several degrees by the end of the century.

It is a useful warning of what could happen if we let the growth of climate-forcing agents run wild. For the sake of contrast, my colleagues and I have defined an alternative scenario for climate change in the 21st Century. In this scenario, the growth rate of the forcing agents that drive climate change decelerates, such that global warming in the next 50 years is less than one degree and the stage is set for stabilizing atmospheric composition later in the century. How can we achieve this? What are the climate forcing agents?

My chart,[1] which is over here, but is also in your handout, shows the estimated climate forcing agents that exist today. Red is used for forces that cause warming, blue for cooling. Carbon dioxide, the bar on the left, causes the largest forcing, 1.4 watts-per-meter-squared. But the forcing by other greenhouse gases, the next four bars, adds up to at least as much as carbon dioxide. Methane causes a forcing half as large as carbon dioxide. Tropospheric ozone is also important; and then there are several aerosols, which are fine particles in the air. Black carbon is soot from diesel engines and coal burning. It causes warming. Organic aerosols and sulfates from fossil fuels cause cooling. Aerosols also affect the properties of clouds (that is the large blue bar here) and cause a cooling, but the magnitude of it is very uncertain. The net forcing by all of these is positive, consistent with observed global warming.

The question is: How will these forcings change in the future? The added climate forcing in the next 50 years will be only one watt and greenhouse warming less than one degree provided, (1) we halt the growth of the non-CO_2 forcings, and, (2) fossil fuel use and CO_2 emissions continue, but at about the same rate as today. The resulting forcing of one watt would cause some climate change, but less than one degree in 50 years.

So, first, can we stop the growth of the non-CO_2 forcing? Not only can we, but it only makes sense. Black carbon is the product of incomplete combustion. You can see it in the exhaust of diesel trucks. The microscopic soot particles are like tiny sponges. They soak up toxic organics and other aerosols. They are so tiny that, when breathed in, they penetrate human tissue deeply. Some of the smallest enter the bloodstream. They cause respiratory and cardiac problems, asthma, acute bronchitis, with tens of thousands of deaths per year in the United States, also in Europe, where the health cost of particulate air pollution have been estimated at 1.6 percent of the gross domestic products.

In the developing world, the costs are staggering. In India, approximately 270,000 children under the age of five die per year from acute respiratory infections caused by this air pollution. The pollution arises in household burning of field residue, cow dung, coal, for cooking and heating. There is now a brown cloud of air pollution mushrooming from India. Tropospheric ozone is another pollutant whose growth could be stopped, as could that of methane. We have only one atmosphere and it is a global atmosphere. We need to reduce the pollution that we put into it for other reasons,

[1] The chart referred to appears in the Appendix on page 62.

human health, agricultural productivity, and in the process we can prevent the non-CO_2 climate forcing from increasing.

In the United States, for example, we can reduce diesel and other soot admissions. We might also work with developing countries to help reduce their pollution. One possible long-term solution would be electrification, a clean source of energy.

Now, the other part of the climate problem is CO_2. It is the hardest part of the problem, but is not as intractable as it is often made out to be.

In 1998, global CO_2 emissions declined slightly. In 1999, they declined again, and, in 2000, another small decline. This is just the trend needed to achieve the alternative scenario with only moderate climate change. In the near-term, my opinion is that this trend can be maintained via concerted efforts toward increased energy efficiency, conservation and increased use of renewable energy sources. On the long-term, we probably need a significant increasing contribution from an energy source that produces little or no CO_2.

In my written testimony, I note some possibilities, which include zero-emission coal; nuclear power; the combination of solar energy, hydrogen and fuel cells. Each possibility has pros and cons, and R&D is needed. It will be up to the public, through their representatives, to make the choices.

Finally, the relevance of all this to your hearing is that there is more than one way to control climate change. The forcing agents that cause climate change are complex and, in some cases, poorly understood. These forcing agents have other effects on people and the rest of the biosphere that should be considered. We need to take a broad view of this issue. We will need a strategy, and that strategy will need to be adjusted as we learn more and see the effect of the actions that we take. This is a long-term issue.

Thank you.

Chairman LIEBERMAN. Thanks, Dr. Hansen. Mr. Karl.

TESTIMONY OF THOMAS R. KARL,[1] DIRECTOR, NATIONAL CLIMATIC DATA CENTER, NATIONAL ENVIRONMENTAL SATELLITE DATA AND INFORMATION SERVICES, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Mr. KARL. Good morning, Mr. Chairman. Thank you for inviting me here today, and Members of the Committee. I have been invited to talk about the science of climate change. First, I want to emphasize two important fundamental issues. First off, there is a natural greenhouse effect. It is real. A small percentage of the atmosphere, about 2 percent, is composed of greenhouse gases. This includes water vapor, carbon dioxide, ozone, and methane. These effectively prevent part of the heat from the Earth escaping and lead to temperatures warmer than what would otherwise be the case.

In addition to the natural greenhouse effect, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements over the past 40 or so years have documented a steady

[1] The prepared statement of Mr. Karl appears in the Appendix on page 68.

growth in atmospheric abundance of carbon dioxide. Measurements, using air bubbles trapped within accumulating layers of snow, show that atmospheric carbon dioxide has increased by more than 30 percent over the industrial era, compared to the relative constant abundance that it had over the previous 750 years.

The predominant cause of the increase in carbon dioxide is the combustion of fossil fuels and burning of forests. Other heat-trapping gases are also increasing as a result of human activities. The increase in heat-trapping greenhouse gases due to human activities are projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. So as atmospheric concentrations of carbon dioxide and greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow, thereby reducing the amount of the Sun's energy reflected back into space, resulting in a higher temperature.

As greenhouse gases increase, evaporation increases, which leads to more atmospheric water vapor. The additional water vapor acts as important feedback to increase temperature. Our present understanding is that these two feedbacks account for about 60 percent of the warming. The exact magnitude of the feedback effects and others, such as changes in clouds, remain a significant source of uncertainty related to our understanding of the impact of greenhouse gases.

Increases in evaporation water vapor affect global climate in other ways besides increasing temperature, such as increasing rainfall and snowfall rates. The increase in greenhouse gas concentration implies a positive radiative forcing and has a tendency to warm the climate. Particles or aerosols in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably from region to region. Some aerosol types act, in a sense, opposite to the greenhouse gases and cause a negative forcing or cooling of climate, as Dr. Hansen's chart shows.

There may also be other natural factors that exert an influence on climate: Changes in the sun's energy, and changes in volcanic eruptions. These effects, however, such as volcanic eruptions, are short-lived. The forcing estimates in the case of greenhouse gases are substantially greater than those for these other two forcing agents. What do the changes imply? First off, there is a growing set of observations that yields a collective picture of a warmer world. There is just simply no question the climate of the last 100 years is increasing the temperature. We have ample evidence: Widespread retreat of glaciers in non-polar regions; snow cover, and sea ice extent has decreased; thickness of sea ice has decreased; and duration of ice on lakes and rivers also all have decreased.

It is also likely that the frequency of extreme events have increased as global temperatures have risen. This is particular evident in areas where precipitation has increased, primarily mid- and high-latitudes of the Northern Hemisphere. Other extremes have decreased, such as the frequency of extremely cold weather, and the frequency of frost during the period of instrumental record. There is a new and stronger evidence that most of the warming over the last 50 years is attributed to human activities. Scenarios

of future human activities indicate continued changes in atmospheric composition throughout the 21st Century.

Based on these scenarios and the estimated uncertainties in climate models, resulting projections of global temperature increase by the year 2100 range from 2.3 to 10.1 degrees Fahrenheit. Such a projected rate of warming would be much larger than observed over the 20th Century and would very much likely be without precedent over the past 10,000 years. It is important to emphasize that greenhouse gas warming could be reversed only very slowly. The quasi-irreversibility arises because of the slow rate of removal from the atmosphere of greenhouse gases and because of the slow response of oceans to thermal changes.

It is presently not possible to generally define a safe level of greenhouse gases. There are still large uncertainties related to the projected rate and magnitude of climate change. The determination of an acceptable concentration of greenhouse gases depends on narrowing this range, as well as the knowledge and risk of vulnerabilities to climate change. Analysis reveals that sectors and regions vary in their sensitivity to climate change, but generally those societies and systems least able to adapt and those regions with the largest changes are at greatest risk. This includes the poor nations and sectors of our society, natural ecosystems—those regions that are likely to see the largest changes, for example, in the Arctic.

In terms of our understanding, there is still considerable uncertainty of how the natural variability of the climate system reacts to emissions of greenhouse gases and aerosols. Current estimates of the magnitude and impacts of future warming are subject to future adjustments either up or down. To address these uncertainties in several areas, we think it is important that we embark on understanding the complex climate system. Progress in this area will be limited by the weakest link in the chain. At the present time, there are several weak links that need to be addressed.

First and foremost, a climate observing system is needed to monitor decade-to-century scale changes for basic variables needed to describe the climate system. Current observing systems yield large uncertainties in several key parameters, especially on regional and local scales. Although we have been able to link observed changes to human activities, it is not possible to quantitatively identify the specific contribution of each forcing factor, which is required for the most effective strategy to prevent large or rapid climate change. This will require better understanding in several areas: The feedbacks of the climate system; the future usage of fossil fuels; carbon sequestration on land and in the ocean; details of regional climate change; and natural climate variability.

Finally, we found that no matter how good our understanding of future climate change might be, we ultimately must understand how this impacts natural and human systems. To achieve this understanding will require first an interdisciplinary research that couples physical, chemical, biological, and human systems, improved capability to integrate scientific knowledge, including its uncertainty, into effective decision support systems, a better understanding of the impact of multiple stresses on human and natural systems, especially at the regional and sectorial level.

Thank you, and I look forward to working with you on these issues, and thank you again for inviting me to appear today.

Chairman LIEBERMAN. Thanks, Mr. Karl. Let me begin questioning. Although we asked you here to discuss the science of climate change, I think it would be interesting to ask if you have any response, having the expertise you do, to the Byrd-Stevens proposal that is the focus of our hearing today, and to the coordination of the response to climate change that it would enact. Do either of you have a response?

Mr. Karl.

Mr. KARL. One thing I would highlight is, as I indicated in my testimony, this is an extremely complex issue, one which encompasses many areas of science. It encompasses areas of social science, as well as the physical sciences. So, to move forward, it is very clear a coordinated effort is clearly needed, and I think that is one of the highlights of the Byrd-Stevens bill.

Chairman LIEBERMAN. Thank you. Dr. Hansen.

Mr. HANSEN. I was delighted to hear the discussions by the several Senators. I agree with Mr. Karl. It is a very complicated issue and we need a broad approach to look at it.

Chairman LIEBERMAN. Do you think that the Byrd-Stevens proposal, as you understand it, meets that standard?

Mr. HANSEN. I do not think it is appropriate for me to take a position with regard to it, but certainly the discussions we heard today seem to be right on the mark.

Chairman LIEBERMAN. Understood. It is my impression that there is not really remaining dispute regarding whether climate change is occurring. In fact, I noticed last week that our colleague, Senator Hagel, who was one of the co-authors, obviously, of the Byrd-Hagel resolution, was quoted in *USA Today* as saying that, "There is no question there is climate change. We are beyond that debate." Would you agree with Senator Hagel, Dr. Hansen?

Mr. HANSEN. Yes, I was one of the authors, as was Mr. Karl, of the recent National Academy of Science's report in which we reaffirmed the reality of global warming and that there is the possibility of disruptive climate change later this century. I think we also took pains to stress some caveats about what will happen. It depends very much on how these climate forcing agents develop, and it is certainly within our capability to influence that and to influence the amount of climate change that will occur.

Chairman LIEBERMAN. Mr. Karl.

Mr. KARL. Yes, there is no question that the climate is changing in ways which we have now seen from the observational record and our past paleoclimate data. One of the important attributes of climate, though, is much broader than just changes in temperature, and as I indicated, there are some unsettling things we do not know about—for example, changes in some of the extreme precipitation events in all areas of the world.

So I think it is really going to be key, as we continue to change atmospheric composition, to look at changes in all the elements of the climate system, particularly for potential surprises, accelerated changes. That is one of the areas I would like to emphasize. Although we are sure climate is changing in significant ways, we do not have all the answers today.

Chairman LIEBERMAN. In other words, there are questions about whether some of the extreme precipitation or extreme weather that people are experiencing is related to the climate change that we know is a reality.

Mr. KARL. Part of the difficulty we have, if you look at our observing system, is that in the mid-latitudes and some of the higher latitudes, we have enough data to make what we think are reasonably confident statements. But if you look at the rest of the world, the observing systems really are not capable of delivering that kind of information which we so badly need.

Chairman LIEBERMAN. One area of focus of the Byrd-Stevens bill, S. 1008, which is, I thought, very interesting, was the need to help us—Americans—adapt to the already inevitable consequences of climate change, or at least that is the way I read one of their four goals. I wanted to ask you to what—perhaps you have answered it already, but just to come at it in a different way—to what extent do you believe that some climate change is already inevitable? In other words, that there will be consequences already. And what measures would you recommend to help adapt to that change?

Mr. HANSEN. I think that we have evidence that some additional warming is on the way. There has been warming already of about half-a-degree Celsius or one degree Fahrenheit in the past century, and I think that there is about another half-a-degree Celsius, which is already in the pipeline, because of the greenhouse gases that we have added to the atmosphere and which the system has not yet responded to, due to the long time constant of the ocean. It takes a long time for the ocean to warm up in response to this forcing.

If we can slow down the growth rate of these climate forcing agents, then I think the additional warming in the next 50 years will be less than one degree. That is a magnitude which we could adjust to probably without a great deal of difficulty, although even now climate fluctuations are a major factor that we need to pay more attention to, making ourself less vulnerable to those fluctuations.

Chairman LIEBERMAN. How serious would the steps be that we have to take to control or contain climate change within the next 50 years, to the degree that you describe?

Mr. HANSEN. Well, there are two things that we need to do: One is, as I mentioned, stop the growth of these non-CO_2 forcings. I think there are very good reasons to do that anyhow, which to a large degree could pay for themselves. They are not going to happen automatically. We have to see that they happen. They are basically air pollution and they affect everybody—I gave numbers for people that die from it—but there are even more people who do not die, but suffer consequences of air pollution.

The CO_2 part: How do we keep the rate of emissions of CO_2 from increasing? Again, that is debatable. There are people who feel that just from conservation, energy efficiency and renewable energy sources, we can keep the emissions similar to what they are today. Most energy experts, however, believe that we will need some clean energy sources such as—I gave you examples: Nuclear power, which has disadvantages; or capture the CO_2 from coal—that is now technically possible, but it adds to the cost. So there are things

that appear practical—but they will require a real effort to do them.

Chairman LIEBERMAN. Mr. Karl, how about your reaction to the extent to which climate change is already inevitable, perhaps also your evaluation of Dr. Hansen's alternative scenario?

Mr. KARL. Yes, I would like to address that and emphasize as well, one of the great problems we face, as Dr. Hansen said, which I agree with, we already have in the pipeline some additional warming, something on the order of half-a-degree, and it is clear that greenhouse gas concentrations are likely to continue to increase. One of the real difficulties we have is trying to ensure that new systems that are expected to have a lifetime of many decades now begin to incorporate, not just the past climate, but projected changes in climate, to ensure that their design efficiency is as good as it could possibly be.

Chairman LIEBERMAN. How do you mean new systems?

Mr. KARL. For example, we have noticed that the design standards for buildings are being exceeded in many parts of the country and engineers are using climatologies based on earlier records in the 20th Century. So in order to ensure that we have efficiency in our energy systems, we would really need to think about how we use the climate of the past and what we might expect into the future, and that is a very important area of adaptation, because quite frankly, at this time, people are a bit scrambling, trying to decide exactly what to do.

Chairman LIEBERMAN. Are we seeing elsewhere, in your experience, the rather dramatic examples that Senator Stevens gave us about what is happening in Alaska and the Arctic region, of the effects of climate change?

Mr. HANSEN. The Arctic region—it is not the entire Arctic. For example, Greenland has actually cooled in the last 50 years. So there is a change in the long-wave patterns at the high latitudes, such that the region around Alaska and the center of Siberia warm substantially. Those are the regions where we have seen the largest warming. I do not think there is a comparable warming in other parts of the world. As we said, the average warming is about half-a-degree Celsius, but in those regions it has been significantly larger than that.

Chairman LIEBERMAN. Go ahead, Mr. Karl.

Mr. KARL. I think it would be worth emphasizing that the expectations of warming are larger over land areas compared to the ocean areas, and large over places like North America and mid- and high-latitudes, significantly larger than the average temperatures that you hear being discussed in terms of projected change.

Chairman LIEBERMAN. Why is that?

Mr. KARL. The oceans are a great reservoir of heat, and we have just conducted some research in our agency which showed that the ocean heat content has increased. So part of the warming being taken up into the oceans is being transported down to deep layers in the ocean.

Chairman LIEBERMAN. But why more of an impact in North America?

Mr. KARL. North America is similar to other major, large continental areas. So you can make the same statement for Eurasia, as well.

Chairman LIEBERMAN. Thank you, both. Senator Thompson.

Senator THOMPSON. Thank you very much, gentlemen. Thank you very much for being with us here today. It seems to me that one of the things that comes out of reading from your works and other experts' work is that there is a great deal of uncertainty and complexity involved in what we are dealing with here, from the work of the National Academy of Sciences and also the U.N. Intergovernmental Panel on Climate Change and others.

Obviously, many are strong proponents of Kyoto, but in 1999, more than 17,000 scientists signed a petition against it. It seems to me that there are questions with regard to the extent of the warming. There are also questions with regard to the causes of the warming. The question presented to us as policymakers is how much do we know at this point and what are the responsible policy options and choices in light of what we know and what we do not know.

Getting to the question of the extent of the warming, I have read—or some scientists have pointed out or alleged—that the climate is always changing and always has. In the Middle Ages, we had another warming trend. Thirty years ago, some people were concerned about climate cooling. Is that technically accurate and, if so, what is the significance of that?

Mr. KARL. I would be happy to address that, Senator. One of the major improvements that we have been able to achieve in the last 5 years is the use of paleoclimatic data or proxy data, and what this encompasses are measurements from tree rings, ice cores, corals in the ocean and historical records. These records have been painstakingly analyzed over the last 5 years by a number of different scientific groups to try and estimate what temperatures have done globally over the last 1,000 years or so. Unfortunately, the measurements are not complete enough to go back 1,000 years in the Southern Hemisphere, but for the Northern Hemisphere, we think they are.

This analysis suggests that our concepts of things like the Little Ice Age, the medieval warming period, perhaps were rooted in the accounts that we read from Europe. If you look at the globe or the hemisphere as a whole, what you see is a remarkable consistency in temperatures across the Northern Hemisphere the last 1,000 years. So when you put on top of that the instrumental record of the 20th Century, you see that the warming that we see in the last 100 years is substantially greater than anything we have seen in the last 1,000 years.

By no means do we have all the answers. We would like to be able to narrow uncertainties. I think the statements we are using now are saying things like, "It's likely that," because we want to leave a little room for additional observations. But the best evidence suggests the warming today is very unusual.

Senator THOMPSON. Can you determine that there have been periods of time in our history where there has been a cooling?

Mr. HANSEN. Certainly there have been. There was a cooling from the 1930's and 1940's until 1970, and that does relate to your

comment about some scientists talking about mechanisms that would cause cooling. That actually is in my chart. The blue bars—the aerosols, most of the aerosols, tend to reflect sunlight and therefore cause a cooling, and it is a possibility that the cooling that we observed in that period was related to the aerosols.

As we started to get our energy systems going, we were producing a lot of aerosols and CO_2. Recently, in recent decades, we have tried to reduce some of those sulfate aerosols, which are pure white and cause a cooling effect. The reason to reduce them being that they cause acid rain and other undesirable things. So it is good to try to reduce those. In the process, though, we accelerate the tendency toward warming. So that is why it is important to also attack not only sulfate aerosols, but the black carbon aerosols, because those aerosols cause warming.

Senator THOMPSON. May I ask this? Do we know enough about this particular subject and this history?

Mr. HANSEN. We do not know enough to——

Senator THOMPSON. Extrapolate that the current trend is going to continue?

Mr. HANSEN. Right, because, you see, there are uncertainty bars on these, the black vertical bars. In fact, the aerosol changes are very uncertain. We do not have the measurements. It is clear we need to try to do some things, and we will need to adjust our strategy as we go along, as we learn more.

Senator THOMPSON. If my suggestion is correct, it does not mean that we should not do anything about it. It does not mean that we should not try to deal with it, or err on the side of safety in the long-term. But it does seem to me, from all I can gather and my limited knowledge of this area, that there is still an awful lot we do not know. It would be very difficult, based on where the science is and where the history and the historical analysis has been, to extrapolate any trend with confidence. It is kind of like budgets and deficits and surpluses around here. Whatever is happening at the moment is what we predict is going to continue to happen. I hope scientists do not do the same thing, but it is a good thing to keep mind, I think, as we go forward.

I also understand that some satellite measurements have been different than others in terms of the extent of the warming. Obviously, you have got regional considerations to take into effect. Some parts of the world are cooling, many are warming. In some cases, surface measurements have been different from satellite measurements—have they not?

Mr. KARL. It is an interesting aspect of trying to understand some of the details of what we see.

Senator THOMPSON. Do not try to make me understand it. We do not have time enough for me to understand all that. But I have a couple more questions, if you can give me a summary.

Mr. KARL. It is clear that if you look at the middle of the atmosphere—I think you were referring to satellite measurements—if you go back to the late 1950's, where we have weather balloons, the middle atmosphere and the surface warming is very comparable. If you look at the last 20 years, a smaller period where satellites have been able to provide additional information, you do find significant differences that we do not entirely understand today.

Senator THOMPSON. Alright, sir. Getting to the causes of warming, Dr. Hansen you especially have made the point that perhaps we are not emphasizing enough the non-CO_2 aspects. I notice this bill creates an Office of Carbon Management and so forth. Obviously, CO_2 is significant, but actually I believe that has been rather stable. CO_2 emissions have been rather stable over a period of time—haven't they—while the other particulates and so forth have gone up?

Mr. HANSEN. The CO_2 emissions have been, in the last 20 years, increasing at about 1 percent a year. That compares with about 4 percent per year from the end of World War II until the oil price shock in the 1970's. So we changed the growth rate from 4 percent to 1 percent. But if we allowed even 1 percent per year growth to continue 50 years, we would be in trouble. So we really need to change that 1 percent to more like 0 percent, and that does require some effort and some technology.

It is often assumed that CO_2 is all the problem or almost all the problem. That is under the assumption that CO_2 emissions continue to increase, so that every year we burn more fossils fuels than the year before, and that is not necessarily true. If we can decrease that growth rate down to 0 percent, then its contribution is not so overwhelming.

Senator THOMPSON. Both of you worked on the National Academy of Sciences report that did an evaluation of the work of the IPCC, and it has been somewhat controversial. The summary that came out was used in the media, in many cases, to say that what you were doing was endorsing Kyoto or certainly at least endorsing the IPCC conclusions.

One of your fellow panelists, Richard Lindzen has written in the *Wall Street Journal* about it, and says, "The panel was finally asked to evaluate the work of the United Nations Intergovernmental Panel on Climate Change, focusing on the summary for policymakers, the only part ever read or quoted. The summary for policymakers, which is seen as endorsing Kyoto, is commonly presented as the consensus of thousands of the world's foremost climate scientists. Within the confines of professional courtesy, the NAS panel essentially concluded that the IPCC's summary for policymakers does not provide suitable guidance for the U.S. Government. The full IPCC report is an admirable description of research activities and climate science, but it is not specifically directed at policy. The summary for policymakers is, but it is also a very different document. It represents a consensus of government representatives, many of whom are also their nation's Kyoto representatives, rather than scientists. The resulting document has a strong tendency to disguise uncertainty and to conjure up some scary scenarios for which there is no evidence." [1]

Would you concur or disagree with his assessment of the work of the NAS in this instance?

Mr. HANSEN. I am disappointed that the media takes such a simple perspective. We reaffirmed that there is some global warming going on, and that there is a danger of large climate change later

[1] The article by Richard S. Lindzen referred to by Senator Thompson appears in the Appendix on page 118.

this century. But that does not lead to the conclusion that therefore the solution to this is Kyoto. We did not address the appropriate policy responses. We did take pains to stress some caveats that should be associated with the IPCC assessment. In particular, right at the very beginning, our second paragraph of the summary, we said that the projections of IPCC that get very large climate change are based on the premise of a business-as-usual scenario, which has larger and larger emissions.

It is not obvious that will happen. In fact, in the last 20 years, there has actually been some deceleration in the rate of growth of climate forcings. The peak rate of growth occurred in 1980 and there has been a 25-percent reduction in that rate, due to the fact that we decided to phase out chlorofluorocarbons and the methane growth rate declined. So that is an example of the kind of strategy, that you can have other benefits from reducing some of these climate forcing agents. That is what we are trying to argue, that we need to look at the entire picture, not just CO_2.

Senator THOMPSON. I am over time, but if you want Mr. Karl to respond to that, it is fine with me.

Chairman LIEBERMAN. Mr. Karl.

Mr. KARL. Commenting on Mr. Lindzen's comment, one of the things, I think, we tried to point out in the Academy report is any time you are necessarily taking a very large volume of work, like if you look at the IPCC full science report, and then you look at the technical summary and the summary for policymakers, it shrinks down. So it is very clear that you do not have the time to or the length of paper to explain all the uncertainties and all of the details of the changes.

So I think it is only natural, when you look at a briefer summary, that you do not spend a lot of time reading all the uncertainties, and clearly they are there in the IPCC report, and often beauty is in the eye of the beholder, and people can take all of those reports and selectively pull out individual sentences and try and craft either a very uncertain future or a very certain future.

Senator THOMPSON. Sometimes commentators or politicians using scientific research and analysis to justify their opinions is not a pretty sight; is it?

Mr. KARL. It is not a pretty sight, but one thing I would say is in Shanghai, as we said in the Academy report, every change that was made to the report—because we went there with a draft—there were suggestions from the floor. They did not understand some comments that were made. They suggested alternative language. But for every change that was made, there was a scientist who was responsible for that section, who formed a group and eventually agreed to whatever change was put into the report on the summary for the policymakers.

Senator THOMPSON. Thank you very much.

Chairman LIEBERMAN. Thanks, Senator Thompson. Senator Voinovich.

Senator VOINOVICH. Thank you, Mr. Chairman. The two of us are on two committees, this Committee and Environment and Public Works, and I am not sure sometimes which committee I am before. I noticed that there is a movement to move climate change into our Subcommittee in Environment and Public Works.

Chairman LIEBERMAN. That is correct.

OPENING STATEMENT OF SENATOR VOINOVICH

Senator VOINOVICH. I thank you for calling this hearing today. I think that this legislation does a good job of calling more attention to the issue of climate change without jumping to some of the conclusions, regarding the science and other issues, which have plagued other approaches. I am pleased, in particular, that it recognizes the need for the continued use of coal. I was interested in Dr. Hansen's comments.

Coal is now and will continue to be the most economical way of producing energy in this country for many years. We have a 250-year supply of coal and we need to encourage clean-coal technologies. Unfortunately, Mr. Chairman, the previous administration was anti-coal and did everything it could to discourage its use, instead of promoting clean-coal technology and working with the utilities to improve their emissions to protect the environment and public health, and to provide low-cost energy.

I sincerely believe that until we pass a multi-emissions bill and deal with the issue of new source review, that we are not going to be able to utilize the technology available for coal so that we can have low-cost energy and move forward with improving our environment. The same applies to nuclear power. We cannot examine climate change and a national energy policy and ignore the fact that nuclear power is something that should be looked at, and again, until we deal with the political football of what we do with nuclear waste, we cannot move on with that option. But it is one that we need to move forward with.

As you know, Mr. Chairman, we did have a hearing in the Public Works Committee which examined the state of the science in terms of climate change, and I was impressed with the fact that there are still many uncertainties regarding climate change and the state of consensus on the issue is, I think, greatly exaggerated by climate change proponents and most members of the press. I noticed that Senator Thompson mentioned Dr. Lindzen's testimony and I am going to ask if that testimony that he gave in the hearing can be inserted in the record for today.[1]

Chairman LIEBERMAN. Without objection

Senator VOINOVICH. I am encouraged, although I think that President Bush handled this Kyoto Treaty issue—maybe from a public relations point of view, he could have handled it differently, because I know that Europeans are up in arms, and I ran into that when I was at the Organization for Security and Cooperation meeting in Europe and also at a NATO meeting. But I am encouraged that President Bush announced last week a broad policy initiative to further study climate change and the potential impacts, including an important joint venture with Japan to develop state-of-the-art climate modeling.

The models that the U.N.'s IPCC has relied upon need additional research before we base a major policy initiative on them, such as what is called for by the European Union. We have to really im-

[1] The prepared testimony before the Senate Environment and Public Works Committee by Richard S. Lindzen on May 2, 2001 appears in the Appendix on page 120.

prove the modeling substantially. I think this legislation is a positive step forward in the sense that it is bipartisan and tries to answer the many uncertainties involved with this issue.

My concerns with the legislation are the costs, which are substantial, and whether or not creating a new bureaucracy in the Department of Energy and in the White House is going to enhance our ability to deal with this challenging problem or whether it is going to make it even more difficult. It authorizes some $4.8 billion, and I am interested in finding out how much is already appropriated to various agencies and departments for climate change and whether or not there is an overlap in terms of the funding.

In addition, I would like to make sure that the new offices in the Department of Energy and the White House actually reduce bureaucratic burden instead of increasing it. I want to again underscore what Senator Thompson said, and that is the National Academy of Sciences, in their report, said, "Because there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments either upward or downward, and reducing the wide range of uncertainty inherent in current model predictions of global climate change will require major advances in understanding and modeling of both the factors that determine atmospheric concentration of greenhouse gases and aerosols and the so-called feedbacks that determine the sensitivity of the climate system and prescribed increase in greenhouse gases. There is also a pressing need for a global observing system designed for monitoring climate."

It is really important that Senator Byrd and Senator Stevens are trying to bring some more objective evaluation of where we are to this subject. Would you agree that we need a whole lot more work in this area?

Mr. HANSEN. Yes, absolutely. I have been arguing for some years that—some people would say that the error bars that we have on these forcings are actually underestimated—that we have to measure what things are actually changing. If we are going to project the future, we have to know what is happening now.

Mr. KARL. There is absolutely no question, as I indicated in my oral statement, that we need fundamental observations for the long-term, not just a 2- or 3-year effort. We need to make sure that we put into place an observing system that can guarantee 50 years from now that we will know what actually happened to some of these very important variables that we have discussed here today.

Senator VOINOVICH. This legislation funds clean-coal technology, and Dr. Hansen, you mentioned that. With your understanding of the science today, do you believe it is possible to address the concerns of the climate change proponents and continue to rely upon the burning of our current coal levels?

Mr. HANSEN. Coal has at least two—it has several emissions. Black carbon is one of them. I think that scrubbing the sulfate and the black carbon is something that can be done. I think that, as you have mentioned, the technology for that has been worked on. That will take care of part of the problem. In the long-run, if coal were to be a major contributor in the next 100 years to our energy

needs, we may also need to actually capture the CO_2. That is possible, and there are now experiments intended to prove that this can be done in an economic way and we can dispose of the CO_2. There are experiments where this is being tested, the CO_2 injected into the ocean, and the ocean can absorb it all. So I think that it is technically possible. We need to support that technology, but it will raise a practical issue because it will increase the cost. We need to make sure that it is not so costly that it would discourage some countries from actually using it.

Senator VOINOVICH. Do you think that it could be compensated with more attention to carbon sinks?

Mr. HANSEN. Carbon sinks, if you mean in the biosphere of forests and soils, there is a limit as to how much you can put there. It can help, but by itself, that is not sufficient if we, in fact, continue to have fossil fuels as a major energy source.

Senator VOINOVICH. And what do you think of nuclear power?

Mr. HANSEN. Again, these types of issues, of course, have to be decided by the people through the representatives, and as you know, there are pros and cons to each of these. Nuclear power, from our standpoint as climate scientists, we can say, "Well, it looks great from that standpoint." It produces essentially no CO_2. So, if it were acceptable, then that is certainly a good candidate for an energy source.

Senator VOINOVICH. I know that you seem to be reluctant to comment about the organizational structure, when you were asked a question earlier.

Mr. HANSEN. I do not think it is appropriate really, for me to do that.

Senator VOINOVICH. May I ask you this? We have the Department of Energy, President Clinton had a task force with the Council on Environmental Quality in the White House, and there are many agencies right now that are dealing with this issue. From your observation, do you think that these activities are well coordinated?

Mr. HANSEN. I think there is a NAS report—Mr. Karl can put in his word here, too, but I think there is pretty widespread agreement that it is not as coordinated as it should be.

Mr. KARL. As I mentioned earlier, this is an exceedingly complex issue, ranging from understanding the physical aspects of the climate system down to the impacts, and I must tell you one of the most frustrating experiences as a scientist is when you try and go interdisciplinary and try and link up the information from one specific scientific specialty to others, to really understand almost every problem we have, relate to multiple stresses. It really requires a lot of coordination. So the statement that it is not nearly as well-coordinated as it could be, I think goes without saying.

Senator VOINOVICH. So you would both agree that, whether through this proposed legislation or some other vehicle, there is a need for better coordination between all of the agencies that are dealing with this problem?

Mr. KARL. Yes.

Senator VOINOVICH. Thank you.

Chairman LIEBERMAN. Thanks, Senator Voinovich. Senator Collins.

OPENING STATEMENT OF SENATOR COLLINS

Senator COLLINS. I want to begin by thanking you for holding this hearing. Climate change is a serious and growing problem. Global temperatures have increased by approximately 1 degree over the last 100 years. According to the scientific community, much of this warming is likely due to human activities that have increased greenhouse gas concentrations in the atmosphere. This warming is expected to accelerate. The best predictions forecast an increase in global temperatures of anywhere from 2.5 to 10 degrees by the end of the next century.

According to a report recently prepared by the National Academy of Sciences, such warming could well have serious adverse effects, including droughts, floods, sea level rise, and far-reaching changes to ecosystems. Senator Byrd and Senator Stevens deserve praise for their efforts to address the difficult issue of climate change by crafting legislation that would position the United States to address climate change in a comprehensive manner and with adequate resources.

I am therefore very pleased to join the Senators as a co-sponsor of their legislation. By more than doubling authorized funds for research and development to create new technologies to deal with climate change, this legislation would significantly advance the United States' efforts to address climate change, as well as better position the United States to become a leader in the energy technologies of the future. The Climate Change Strategy and Technology Innovation Act is an important step in creating an appropriate U.S. response to climate change.

But, Mr. Chairman, I would suggest that it is not the only step that we should take. We also need to continue making improvements in energy efficiency, further develop our renewable energy resources, and take action to reduce emissions. In fact, the Chairman and I are co-sponsors of legislation that would attempt to bring about those changes. By taking these actions in combination with the groundbreaking legislation proposed by Senator Byrd and Senator Stevens, I believe that we can create an energy strategy that will save consumers money, make America less dependent on foreign energy sources, and protect society and the environment from the detrimental effects of climate change.

Mr. Chairman, I am very fortunate to have on my staff a climatologist. I suspect that I may be the only Senator who is not a member of the Environment Committee that has a climatologist on my staff, and I have to tell you that he speaks very highly of the work done by the two scientists who are appearing before us today.

Dr. Karl, my staff tells me that you have done groundbreaking work on the analysis of global temperature trends, and your work has made a significant contribution to our knowledge of global warming. Given your expertise on measuring temperature trends, could you discuss an issue that I understand has been hotly debated with climate change, on the differing results between ground-level and satellite measurements of temperature trends.

I understand that ground-level measurements have often shown greater warming than satellite measurements. So the question that comes to my mind: Is there a problem with one set of measure-

ments or are ground temperatures really warming faster than those in the lower atmosphere?

Mr. KARL. That is a very good question, Senator, and I will try to briefly answer that. As I indicated earlier to Senator Thompson, that if we take a look at the temperatures in the middle part of the troposphere, they have been measured by satellites since 1979. If we go back farther in time, using weather balloons, we can get an estimate of the temperatures in the middle part of the troposphere back to 1960. If we see what is happening at the surface and compare that to the middle part of the troposphere, we find a reasonably consistent picture over that longer 40-year period. If we focus on the last 20 years, we find a significant difference.

Part of that difference, we think we understand in terms of the timing. It is a short record, remember, 20 years, the timing of El Nino events, the timing of volcanic eruptions—Mount Pinutubo, for example, all have big effects in a short record. Also the way in which the Earth is sampled differently from ground-based measurements compared to balloons and from satellite data impacts the difference. So we can go some way toward explaining the difference in the last 20 years, but part of that difference still remains unexplained and it is one of the challenges of the scientific community to understand.

Now, are there still problems with both surface and tropospheric temperature measurements? Certainly we try to put error bounds on the data, and we think even given the error bounds that we put on these two different sets of measurements, in the troposphere and at the surface, there still remains an unexplained physical difference that we do not quite have resolved yet today.

Senator COLLINS. Thank you.

Dr. Hansen, I have a question for you, also. In your written testimony, you speak extensively of the importance of combating air pollution as a means of addressing climate change. As you point out, this would have substantial collateral benefits. Your statistics on the impact of air pollution in Europe are really stunning: 40,000 deaths and 500,000 asthma cases a year in France, Switzerland, and Austria alone. In your judgment, does the Kyoto Protocol adequately and efficiently address the global warming impacts of black carbon and other forms of air pollution?

Mr. HANSEN. No, it does not. It, in fact, does not include black carbon. It does not include tropospheric ozone. As you notice in my chart, if you add up our estimates of those two forcings, it is comparable to that of CO_2, and I think it is important that they be included. Given the difficulty, the cost of the kind of agreements that you would need for the Kyoto Protocol, I just do not see us having two of these. So I think it makes much more sense to combine the air pollution issue and the CO_2 issue, otherwise we are just not giving enough attention to this aspect of the problem.

I do not know how many people are dying from global warming right now, but I do not think it is very many, and I do not think there are as many people being affected by that. So it is just inappropriate to neglect this air pollution aspect.

Senator COLLINS. And that does appear to be a significant weakness of the Kyoto Protocol.

Mr. HANSEN. In my personal opinion, yes.

Senator COLLINS. Thank you, Mr. Chairman.

Chairman LIEBERMAN. Thanks very much, Senator Collins. I remember being at a seminar on global warming in which—this was one of those Aspen programs in which we had a bunch of scientists talking to a bunch of us members of Congress, and one member of the House, who happened to be a Republican, at the end said—it was Jim Greenwood who said, "So let me get this straight," to the scientists, "If you are right," and they were mostly very proactive about global warming, "and we take appropriate remedial action, we will have saved the planet as we know it. And if you are hyperventilating a bit, all we will have done is to clean up the air and keep a lot of people healthier than they otherwise would be." So, not a bad trade-off. Thank you.

Senator Bennett, thanks for being here.

OPENING STATEMENT OF SENATOR BENNETT

Senator BENNETT. Thank you very much, Mr. Chairman. If I may, I would respond to that with another set of trade-offs. There is no agreement in the scientific community about what is causing global warming. There are hypotheses that are vigorously argued one side or the other. There is, as nearly as I can tell, absolute agreement in the economic community that Kyoto would be a disaster, economically, to the United States, if it were to be put into place. My point is that the greatest enemy of the environment is poverty.

Dr. Hansen has talked about India and the brown cloud that hangs over India. The reason India puts up with that is not that they like air pollution, but that they cannot afford in their economy the kind of scrubbers that we have. So if we go chasing down the cliff, and I consider it a cliff, of Kyoto, we run the risk of impoverishing the economy that drives the rest of the world, and thereby end up with people in underdeveloped countries causing greater global warming than otherwise. So I would have argued with your Republican friend if I had been present at that particular Aspen Institute.

Dr. Hansen, I do not want to mousetrap you or blindside you in any way. I have here a report written by Patrick Michaels. Are you familiar with Mr. Michaels?

Mr. HANSEN. Yes, I am.

Senator BENNETT. Rather than debate it, I would ask you to supply for the record your rebuttal to Mr. Michaels' argument, so that those who do not know what we are talking about will understand this. I am quoting from this report, he says, "NASA scientists—on June 23, 1988, NASA scientist James Hansen testified before the House that there was a strong cause-and-effect relationship between observed temperatures and human emissions into the atmosphere," and then you presented a model based on that assumption where you predicted an increase of .45 degrees centigrade from 1988 to 1997, and Mr. Michaels has a chart where he shows that prediction was wrong on the high side by a fairly significant amount.

I would appreciate it if you would respond to that chart and give us your analysis. If you can do it quickly here——

Mr. HANSEN. Yes, I would like to quickly respond to that. It is a very curious charge, because, in fact, if you look at my 1988 testimony, what I showed was three scenarios for the future. One of them, scenario A, was business-as-usual, in which the emissions increase, every year you have more than before, and the other—scenarios B and C had more flat emissions. In fact, the real-world emissions have been between scenarios B and C. If you look at our climate model calculations for the forcings which have actually occurred, they are right on the money. So Mr. Michaels did a very interesting thing. He took our chart—by the way, in the Senate testimony I said——

Senator BENNETT. In the House testimony.

Mr. HANSEN. In my Senate testimony in 1988——

Senator BENNETT. Oh, OK.

Mr. HANSEN. I testified to both the House and Senate in 1988 and showed exactly the same projections—but I said the most likely scenario is scenario B, not scenario A. But Mr. Michaels took this chart, erased scenarios B and C, and showed scenario A. So it is a very simple answer to this.

Senator BENNETT. I appreciate that, because I suggest or believe that the *New York Times* has taken scenario A and enshrined it in conventional wisdom forever and ever, as they tell us what scientists are saying. I appreciate your clarifying that, because what you are saying is that there is no absolute certain prediction upon which everybody can depend with respect to the future. There is a great deal of uncertainty.

Mr. HANSEN. That is exactly right. There is no reason that we need to follow scenario A, the business-as-usual.

Senator BENNETT. You are saying now that we did not follow the scenario——

Mr. HANSEN. We have not, no. I mentioned a little earlier that, in fact, the growth rate of emissions declined 25 percent in the last two decades because of chlorofluorocarbons being phased out and because of methane slowdowns. So we have already taken some very helpful steps for reducing the future climate change and we need to take some more in the next century.

Senator BENNETT. I would hope that if there is any representative of the *New York Times* here, that they would call your answer to the attention of their editorial writers, so that they could become a little less hysterical.

Mr. HANSEN. I actually tried to do that. I wrote an op-ed article a week ago, but they did not publish it.

Senator LIEBERMAN. We can sympathize with that. [Laughter.]

Senator BENNETT. You will not get opinions that are not fully orthodox ever reported in the *New York Times,* unless you can get Bill Sapphire to write the column about it.

Chairman LIEBERMAN. That explains why I like those editorials, they are fully Orthodox. [Laughter.]

Senator BENNETT. Very good. You have maybe answered this question, but I would like you to get into it a little bit more. We are talking about temperatures going up in the last 100 years. In fact, they went up for 30 years. They went down, admittedly at a lower angle than they went up, for about 30 years, and then they

started up again for 30 years. So, instead of this being the chart for the last century, it is this, this, and this. [Indicating.]

Can you tell us what caused that 30 years of temperature going down, roughly between 1945 and 1975?

Mr. HANSEN. We cannot do it with confidence. It could be unforced variability. The climate system is a chaotic system, which fluctuates from decade to decade, just like the weather fluctuates from day to day, because the atmosphere and ocean are fluids, which are chaotic and have an unforced variability. It could also have been forced. As you know, as we have talked some time today, there are both positive forcings and negative forcings, and the negative forcings probably—the aerosols have not been increasing so much recently. In fact, in the United States and Europe, they have been decreasing because of acid rain concerns. It could be that the aerosol increases caused that cooling trend, but we do not have the measurements to prove that.

Senator BENNETT. You are underscoring once again the uncertainty here.

Mr. HANSEN. Right.

Senator BENNETT. We do not really know what caused it to go up so rapidly in that first 30-year period or what caused it to come down in 30 years. We think we have got a better handle on what is causing it to go up now, but even there, we cannot be absolutely sure. Is that a fair statement?

Mr. HANSEN. That is exactly right.

Senator BENNETT. One final question. As I looked into this, I asked a layman's question and was a little stunned at the answer that I got. I hope you can help me understand it. I said, "How much CO_2 is there?" We talk about CO_2. How much CO_2 is there and what percentage of it comes from human activity? I am told that roughly three—maybe generously 4 percent—of the total CO_2 that the planet has released into the atmosphere every year comes from human activity, and that the rest of it is all generated by the planet itself.

My question is, is there a difference out there in the atmosphere or troposphere or wherever it is you wander, between naturally-generated CO_2 and human-generated CO_2? Let me tell you why I want to know that. Because if indeed there is no difference—let's take the 4 percent number, which is the largest number I have heard for human activity generating CO_2, and take the 25 percent figure, which the *New York Times* quotes as coming from the United States, that means the United States is producing 1 percent of the total CO_2 out there, and if we do Kyoto, we reduce that by less than $\frac{1}{10}$ of 1 percent. I wonder why savaging the American economy to reduce the total by less than $\frac{1}{10}$ of 1 percent is a good idea.

Now, that is where the math is. Once again, is there a difference in the atmosphere between naturally-generated CO_2 and human-generated CO_2 that affects this whole equation?

Mr. HANSEN. There is not a difference which is relevant to their ability to cause warming. However, I do not understand where your 4 percent comes from, because there are various ways to do these numbers.

Senator BENNETT. It comes from the Department of Energy and cross-checked with the Congressional Research Service at the Library of Congress.

Mr. HANSEN. Let me tell you what I think the relevant numbers would be. Prior to the Industrial Revolution, the amount of CO_2 in the atmosphere was about 280 parts-per-million. It did change over time scales of tens of thousands of years with the Ice Ages and things, but the last several thousand years it was about 280 parts-per-million. It is now about 360—is that right, Mr. Karl? So it is about a 25- or 30-percent increase, and we are pretty darn sure that that is almost entirely due to human activity. So, based on those numbers, it is not a 4 percent increase. It is more like a 30 percent increase, and the United States has contributed a fairly large fraction of that.

Senator BENNETT. Clearly, we need a resolution to this, because I have gone to every source I could find to say what percentage of the total CO_2 currently being sent into the atmosphere comes from human activity, and the answers have been amazingly uniform.

Mr. HANSEN. The way you get that small number is to look at the fluxes. There are fluxes that go up and down, because the plants are growing and decomposing—there are fluxes up and down. But the point is, if you look at those total fluxes, yes, the human contribution may not look so large. But the net impact of that human contribution—it is always one sign. Humans are the cause almost certainly for almost all of this increase from 280 parts-per-million to 360 parts-per-million.

So I think it is more appropriate to say that humans have contributed an increase to atmospheric CO_2, which is about 30 percent of what is there now. There is really no scientific disagreement about this.

Chairman LIEBERMAN. You got your answer, Senator Bennett.

Senator BENNETT. I will go back to the Department of Energy and the Library of Congress now and see what comment they have.

Chairman LIEBERMAN. Thanks very much. You raise some important questions, including the ones about the economic consequences of Kyoto, which I believe that some of our witnesses on the second panel will testify to. If they do not, I am going to ask them about it. Thanks to both of you.

Did you want to respond at all, Mr. Karl, to Senator Bennett's questioning?

Mr. KARL. I might just want to make one statement, and that is absolute certainty is very rarely going to be found in these complex environmental issues. So when we say we are nearly certain, that is pretty high statement coming from scientists in an area that is fairly uncertain.

Chairman LIEBERMAN. Thanks very much to both of you. I would like to now call the final panel: Eileen Claussen, President of the Pew Center on Global Climate Change; Dr. James Edmonds, Senior Staff Scientist, Pacific Northwest National Laboratory, Battelle Memorial Institute; Dale E. Heydlauff, Senior Vice President, Environmental Affairs, of the American Electric Power Company; Jonathan Lash, President of the World Resources Institute; and Margo Thorning, who is Senior Vice President and Chief Economist of the American Council for Capital Formation.

Thanks to all of you for coming this morning. We really look forward to your testimony about the Byrd-Stevens legislation and about the problem overall.

Ms. Claussen, welcome back.

TESTIMONY OF EILEEN CLAUSSEN,[1] PRESIDENT, PEW CENTER ON GLOBAL CLIMATE CHANGE

Ms. CLAUSSEN. Thank you very much, Mr. Chairman and Members of the Committee. Thank you for this opportunity to testify on S. 1008, the Byrd-Stevens Climate Change Strategy and Technology Innovation Act of 2001. My name is Eileen Claussen and I am the President of the Pew Center on Global Climate Change. The Pew Center on Global Climate Change is a nonprofit, nonpartisan and independent organization dedicated to providing credible information, straight answers and innovative solutions to the effort to address climate change. Thirty-six major companies in the Pew Center's Business Environmental Leadership Council, most included in the Fortune 500, work with the center in assessing the risks, challenges and solutions to climate change. There is a list of who they are up there on the chart.

Mr. Chairman, I believe that enacting the Byrd-Stevens bill will be an important first step in developing a serious domestic climate change program, a step that should be taken quickly. This bipartisan bill will integrate our energy policy with the long-term goal of stabilizing atmospheric greenhouse gas concentrations. It will respond to concerns often raised by other nations that the United States has no basis for domestic action. It will continue investigation into the uncertainties of the science and economics of climate change.

Most important among the many provisions of the Byrd-Stevens bill is the one that requires the development within 1 year of a U.S. climate change response strategy with the objective of stabilizing greenhouse gas concentrations. To meet this goal, the strategy will rely on emission mitigation measures, technology innovation, climate adaptation research, and efforts to resolve the remaining scientific and economic uncertainties.

At the Pew Center, we believe enough is known about the science and environmental impact of climate change for us to take action now. As we have learned from the Intergovernmental Panel on Climate Change, confirmed recently by the National Academy of Sciences, the scientific consensus is very strong that greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise.

As a consequence, there likely will be substantial impacts to human health, agriculture, ecosystems and coastlines. The high probability of these outcomes indicates the need for some action now. Even as we act, however, we need to refine our scientific understanding, particularly on the impacts of climate change. But the best scientific evidence tells us that we have already bought a changed climate, to which we and our children will need to adapt.

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[1] The prepared statement of Ms. Claussen appears in the Appendix on page 75.

Obviously, the more quickly we mitigate, the less we will have to adapt. But some amount of adaptation appears inevitable. The Byrd-Stevens bill creates a sound basis for giving priority to and investigating how we must adapt to climate change. We also applaud efforts to further analyze the uncertainties regarding the economic impacts of climate change. Work done by the Pew Center suggests that no existing model accurately predicts the economic effects of any given measure to mitigate climate change. We are hard at work to fill in many of the gaps of the models, but additional efforts would be most welcome.

Second, the Byrd-Stevens bill will promote technology innovation. In May, Senator Byrd said from the Senate floor that to address global climate change, "What is required is the equivalent of an Industrial Revolution." We think he was exactly right. To effectively address climate change, we need to lower carbon intensity, become more energy efficient, promote carbon sequestration, and find ways to limit emissions of non-CO_2 gases. This will require fundamentally new technologies, as well as dramatic improvements in existing ones.

New, less carbon-intensive ways of producing, distributing and using energy will be essential. The redesign of industrial processes, consumer products and agricultural technologies and practices will also be critical. These changes can be introduced over decades as we turn over our existing capital stocks and establish new infrastructure. But we must begin making investments, building institutions and implementing policies now.

Third, under the Byrd-Stevens bill, the climate change response strategy will be required to incorporate mitigation approaches to reduce, avoid and sequester greenhouse gas emissions. This will force us to take a hard, needed look at our policy choices. We believe that it will be extraordinarily difficult, if not impossible, to muster the kind of sustained effort needed to reduce, avoid and sequester greenhouse gas emissions without the force of legally-binding commitments.

There is little incentive for any company to undertake real action unless ultimately all do and are in some manner held accountable. Markets, of course, will be instrumental in mobilizing the necessary resources and know-how. Market-based strategies, such as emissions trading, will also help deliver emissions reductions at the lowest possible cost. But markets can move us in the right direction only if they are given the right signals. In the United States, those signals have been neither fully given, nor fully excepted.

Three decades of experience fighting pollution in the United States have taught us a great deal about what works best. In general, the most cost-effective approaches allow emitters flexibility to decide how best to meet a given limit, provide early direction so targets can be anticipated and factored into major capital and investment decisions, and employ market mechanisms to achieve reductions where they cost least. To ease the transition from established ways of doing business, targets should be realistic and achievable. What is important is that they be strong enough to spur real action and to encourage investment and development of the technology and infrastructure needed to achieve the long-term objective.

A good first step to get our house in order is to immediately require accurate measurement, tracking, reporting and disclosure of greenhouse gas emissions. In addition, the government could enter into voluntary enforceable agreements with companies or sectors willing to commit to significant reductions. While such efforts can help get the United States on track, the long-term emission reductions needed can be achieved only with a far more comprehensive and binding strategy.

I should add that congressional debate over the mitigation measures should start now and not await completion of the strategy, especially since the debate will take some time, we believe, to resolve. As Senator Byrd said when he introduced his bill, this legislation is intended to supplement, rather than replace, other complementary proposals to deal with climate change in the near-term on both the national and international level.

In closing, Mr. Chairman, the Byrd-Stevens Climate Change Strategy and Technology Innovation Act of 2001, if enacted quickly and implemented in a serious manner, will provide an excellent foundation for climate change policy in this country. Thank you for the opportunity to testify.

Chairman LIEBERMAN. Thank you, Ms. Claussen, for that excellent testimony.

Dr. Edmonds, welcome. Thank you for being here.

TESTIMONY OF JAMES A. EDMONDS,[1] Ph.D., SENIOR STAFF SCIENTIST, PACIFIC NORTHWEST NATIONAL LABORATORY, BATTELLE MEMORIAL INSTITUTE

Mr. EDMONDS. Thank you, Mr. Chairman and Members of the Committee, for the opportunity to testify here this morning on the Climate Change Strategy and Technology Innovation Act of 2001. It is a privilege to be invited here and to have the opportunity to share a position on this panel with such distinguished colleagues as Dale Heydlauff, as well as, Eileen Claussen, Jonathan Lash, and Margo Thorning. My presence here today is possible because the U.S. Department of Energy, EPRI and numerous other organizations in both the public and private sectors have provided me and my research team at the Pacific Northwest National Laboratory long-term research support.

That having been said, I come here today to speak as a researcher and the views I express are mine alone. The focus of my comments today are on the funding portion of the Climate Change Strategy and Technology Innovation Act of 2001, not on its organizational aspects.

My observations draw upon the work that was conducted under the Global Energy Technology Strategy Program to Address Climate Change, an international, public-private sector collaboration advised by an eminent Steering Group. Analysis conducted at the Pacific Northwest National Laboratory, as well as in collaborating institutions around the world during Phase I, supports three general conclusions: (1) It's concentrations of greenhouse gases that matter. For CO_2, cumulative emissions by all countries, over all time determine the concentration; (2) technology is the key to con-

[1] The prepared statement of Mr. Edmonds appears in the Appendix on page 79.

trolling the cost of stabilizing the concentration of greenhouse gases; and (3) managing the cost of stabilizing the concentration of greenhouse gases, at any level, requires a portfolio of energy R&D investments across a wide spectrum of technology classes.

My first point is that: It's Concentrations Not Emissions. The United States is a party to the Framework Convention on Climate Change, which has as its objective the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." This is not the same as stabilizing emissions. Because emissions of the greenhouse gas, CO_2, accumulate in the atmosphere, its concentration will continue to rise indefinitely even if emissions are held to current levels or even at some reduced level.

Stabilization of CO_2 concentrations means that the global energy system, and not just the United States' energy system, must undergo a fundamental transition from one in which emissions continue to grow throughout this century into one in which global emissions eventually peak and then decline.

Coupled with significant global population and economic growth, this transition represents a daunting task even if a concentration as high as 750 parts per million is eventually determined to meet the goal of the Framework Convention—though no consensus yet exists as to what concentration will prevent "dangerous" interference with the climate system.

My second point is that: Technology Controls Cost. Stabilizing the concentration of greenhouse gases in the atmosphere will require a credible commitment to limit cumulative global emissions of CO_2. Such a limit is unlikely to be achieved without cost but that cost will in large measure be shaped by the character of the energy technology options available to limit cumulative global emissions of CO_2.

My third point is that: There Is No "Silver Bullet." No single technology controls the cost of stabilizing CO_2 concentrations under all circumstances. The portfolio of energy technologies that is employed varies across the world's regions and over time. Regional difference in such factors as resource endowments, institutions, demographics and economics, inevitably lead to different technology mixes in different nations, while changes in technology options inevitably lead to different technology mixes over time.

Technologies that are potentially important in stabilizing the concentration of CO_2 include energy efficiency and renewable energy forms, non-carbon energy sources such as nuclear power and fusion, improved applications of fossil fuels, and technologies such as terrestrial carbon capture by plants and soils, carbon capture and geologic sequestration, fuel cells, and advanced energy storage systems, and commercial biomass and biotechnology. The latter holds the promise of revolutionary change for a wide range of energy technologies. Many of these technologies are undeveloped or play only a minor role in their present state of development.

Mr. Chairman, thank you for this opportunity to testify. I will be happy to answer your and the Committee's questions.

Chairman LIEBERMAN. Thanks, Dr. Edmonds. Thanks very much.

Mr. Heydlauff, welcome.

TESTIMONY OF DALE E. HEYDLAUFF,[1] SENIOR VICE PRESIDENT-ENVIRONMENTAL AFFAIRS, AMERICAN ELECTRIC POWER COMPANY

Mr. HEYDLAUFF. Thank you very much, Mr. Chairman. It is a privilege to be here, Senator Thompson, Senator Bennett. My name is Dale Heydlauff. I am the Senior Vice President for Environmental Affairs at American Electric Power Company. We are headquartered in Columbus, Ohio, and have the distinction of being the country's largest consumer of coal. As a matter of fact, I think we burn more coal than anybody in the Western Hemisphere. We are the third-largest consumer of natural gas. We are the largest producer of electricity in the Nation.

As a consequence of that, we recognized early on that the concerns about global climate changes were ones that we needed to take seriously. We have been heavily engaged in the debate since literally Dr. Hansen testified before the Senate in 1988. We have been following this debate very closely. We have been participants and observers in the international negotiations on this issue, and importantly, we have sought to find and identify ways that we can effectuate meaningful emission reductions, avoidance or sequestration through our activities and our operations, both domestically and around the world.

It is in that context that I wanted to testify before you today, and with your permission, I will submit my written statement for the record and just summarize my oral remarks. The simple thing for me to do is just to say I concur completely with the statements of those who have preceded me on this panel. We are one of the founding members of the Pew Center on Climate Change Business Environmental Leadership Council and we are honored to be in that position. I rarely find myself in disagreement with the wisdom of our President, Mrs. Claussen. Dr. James Edmonds and I have known each other for a number of years now. The Global Energy Technology Strategy Program that he referenced in his testimony is research that we helped fund and have funded for years. Quite honestly, it has guided substantially what I want to say here today.

Let me start and say if I could summarize my remarks in one line, it would be this: Accelerating climate friendly technology development through very dramatic increases in energy technology, research and development, both by the public and private sectors, and then deploying the fruits of that R&D on a global basis is by far and away, in my judgement, the most sensible, cost-effective and ultimately sustainable strategy for addressing the climate change issue.

I do not think there is going to be any other way you are going to do it. If you believe that atmospheric concentrations of greenhouse gas emissions need to be stabilized in the future, it is only going to come about as a result of a technology strategy, one that can help be facilitated by the legislation that we are testifying to today. Let me talk a little bit about the challenge that befalls this country in doing that, and indeed the world, because this is truly a global commons problem.

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[1] The prepared statement of Mr. Heydlauff with an attachment appears in the Appendix on page 84.

The first is, in real terms, energy technology R&D in this Nation in the past decade has fallen by 47 percent, both in the public and private sectors. The energy industry itself, I am somewhat embarrassed to report, today invests ½ of 1 percent of total national revenues on technology R&D. Compare that to the chemical, pharmaceutical, and telecommunications industries, which routinely spend about 10 percent of annual revenues on R&D, or the U.S. industrial average of 7 percent, and you can see the challenge we have confronting us.

To compound the problem, however, what we are spending our dollars on today could be characterized as evolutionary improvements in existing technology, which certainly have some societal good, and particularly even some climate change benefits, because in many cases we are attempting to squeeze out more efficiency from existing technologies. But it simply is not going to be a successful strategy, because what we really need to do is develop those bold breakthrough technologies that the Byrd-Stevens legislation would help to facilitate.

A couple of other points I wanted to mention, specifically with respect to the Byrd-Stevens legislation. One is I think they have done a commendable job in the construct of the national research program and agenda. First of all, you need leadership, and that leadership can only and should only be governed from the top of the Executive Branch in the White House. I commend them for the establishment of the White House office.

Second, you do need a bureaucracy. I hesitate always to differ with the Senator from my home State, but in this case, I think you do need leadership, you need management of an effort of this magnitude. Third, quite honestly, as significant as the level of expenditures would be under this legislation, they will ultimately be inadequate, and I realize we are just talking about public sector investments with respect to the authorizations that we derive from this legislation, and hopefully the private sector would be willing to step up and come close to matching that level, because you are going to need investments of that magnitude ultimately to be successful.

You look at the four paradigms of the Byrd-Stevens bill, and I think they have got it right. It would establish the solid foundation upon which to address the climate change issue for a very long time to come. So, with that, I would admonish the Committee to exercise the same degree of speed and forthrightness that you took to scheduling this hearing so soon after the legislation was introduced and proceed on to pass it out and send it over to the House.

Thank you very much, Mr. Chairman.

Chairman LIEBERMAN. Thanks very much, Mr. Heydlauff. It strikes me that for somebody who may be either here in the room, and not very familiar with this dialogue that has been going on, or watching on television, that the favorable testimony and very proactive testimony that you have given, representing the company that is the largest consumer of coal, might be surprising, because some might think that you would be avoiding a solution. So I admire the fact, and it is typical of a whole group of companies in a similar position, that you are forward-leaning, are part of the solution, and I know from previous conversation you want the certainty

that will come with a legislative leadership and solution. So I thank you very much for your testimony.

Mr. Lash, welcome back. Good to see you again.

TESTIMONY OF JONATHAN LASH,[1] PRESIDENT, WORLD RESOURCES INSTITUTE

Mr. LASH. Thank you, Mr. Chairman, Senator Thompson, and Senator Bennett. It is a pleasure to be here with you today. I was very struck by Senator Byrd's opening statement and by his co-sponsor Senator Stevens' comments at the beginning of this hearing. These comments are most important because they signify a recognition that climate change is a problem that needs to be systematically addressed and is a priority for our country.

I would actually like to address the legislation that is before us, rather than the science or the strategies that might emerge. Senator Byrd commented, as he did when he introduced the bill initially in the Senate, that this is a part of a broader effort on climate, not a substitute for action, and I want to address it in that context. It is essential that, at the same time, the Senate continue to deal with complementary proposals for addressing the problem of climate change including legislation that Members of this Committee have co-sponsored. I will come back to why I think that this is so important. But S. 1008 is particularly important because it recognizes that climate change represents threat to the Nation's interests and that we need a national climate change strategy that is informed by a public dialogue which can help the country to understand what is at stake in the issue and what is at stake as we approach the solutions.

The strategy should take as its goal, the stabilization of greenhouse gases in the atmosphere at safe levels. That recognition is an important step in our debate. This was the goal accepted by the United States almost a decade ago when then-President Bush signed and the U.S. Senate ratified the Framework Convention on Climate Change. Now the United States does not have a strategy on climate change, and as many commentators have noted, we are clearer about what we are against than what we are for.

Second, S. 1008 recognizes that climate change considerations should be integrated into decision-making at every level of the government. I offer no view about the specific administrative arrangements proposed in the bill and the highly-detailed requirements, but I think that the effort to ensure that climate change considerations enter into energy policy and environmental policy decisions is essential, at all levels of the government.

Third, S. 1008 recognizes that economic consequences of inaction on global warming may cost the global economy trillions of dollars. As Senator Bennett pointed out several times earlier, there is no free effort to respond to climate change and there is a great deal of discussion about the costs of any strategy for a response, but we need to recognize the costs of failure to respond as well.

Fourth, S. 1008 recognizes that current research and development budgets are grossly inadequate to meet the challenge of climate change. As the bill's findings correctly state, stabilization of

[1] The prepared statement of Mr. Lash appears in the Appendix on page 91.

greenhouse gases in the atmosphere will require transformational change in the global energy system, as well as research and development that leads to bold technological breakthroughs. I agree very much with what Mr. Heydlauff said a moment ago about the importance of research that is not just at the margins, but, of research that helps us understand the significant kind of changes that we could make.

Today we have technologies available that companies part of the Pew Center are using to reduce emissions. It is not impossible for us to respond to climate change this week, next week, or next month, to improve efficiency, and to adopt new sources. At the World Resources Institute, we work with a group of companies who will soon purchase several thousand megawatts of wind energy in an effort to reduce their reliance on carbon-based fuels. But none of this is a substitute for large-scale research on major new technologies.

Finally, S. 1008 recognizes that our national energy strategy cannot be shaped without paying close attention to the challenge of climate change. I want to go back to what I said at the start and emphasize again the need for early action. I think there are three reasons for slowly taking action now. First of all, if we begin to slowly take action, we will learn the answers to some of the questions that are troubling many Senators about the costs and technological and social difficulties of change. If we start slowly, we can add to our store of information about how to respond pragmatically.

Second, a slow start gives us a chance to make a stable transition. Mr. Heydlauff's company, I believe, burns 80 million tons of coal a year. Part of the national energy strategy will certainly be to encourage companies like AEP to build new plants for the generation of electricity. I do not know how AEP managers can effectively represent the interests of their shareholders if they do not know what policies government may impose in 5, 6, or 8 years that will add to the costs of burning coal. Without knowing what regulatory costs will be managed, they do not know how much to invest in efficiency, how much to invest in gas, how much to invest in pollution controls.

Finally, I do not think it is to the benefit of the United States' competitiveness to fail to invest in more efficient technologies for producing energy. Whatever long-term strategy we ultimately develop to try to stabilize concentrations, what we do in the first 10 years will likely have to be the same. Whatever the path we ultimately are going to follow, it will still involve early efforts to reduce pollution and control CO_2.

Thank you very much, Mr. Chairman.

Chairman LIEBERMAN. Thank you very much, Mr. Lash, for that very interesting testimony.

Ms. Thorning, thanks for being here. We look forward to hearing you now.

TESTIMONY OF MARGO THORNING,[1] Ph.D., SENIOR VICE PRESIDENT AND CHIEF ECONOMIST, AMERICAN COUNCIL FOR CAPITAL FORMATION

Ms. THORNING. Thank you very much. I appreciate the opportunity, Mr. Chairman, to appear before this Committee and to appear with such a distinguished panel of climate policy experts. I would like to request that my written testimony be included in the record.

Chairman LIEBERMAN. It will, without objection.

Ms. THORNING. My written testimony includes a discussion of some of the issues you asked about, including the macroeconomic impact of the Kyoto Protocol and near-term emission limits, the impact on U.S. budget surpluses of actions that would slow economic growth, international trading systems, and a discussion of the fact that the European Union itself will not be able to meet its Kyoto targets, and a discussion of the science. Although I am not a scientist, I did want to raise the issue that, as we heard earlier, the science is not clearly understood. Much further work, much more study, needs to be done on that.

Before launching into a little discussion of S. 1008, I would like to draw your attention to the story on the front page of the *Washington Post* this morning, Steven Pearlstein's story about the economic impact of global slowdown. The implication of the Pearlstein story is the United States is the engine of world economic growth. If we are unable to regenerate the strong growth that we have experienced in earlier years, it is going to be much harder for the developing economies and for Europe and for Japan to pull themselves out of their slump.

Therefore, I think it is appropriate to weigh very carefully any major policy decisions, such as measures to, in the near-term, sharply reduce the growth or cap CO_2 emissions. The studies that we have looked at and that are described in my testimony suggest such policies would reduce U.S. levels of GDP by 2 to 4 percent a year, which would be a significant negative drag on the U.S. economy and on our trading partners. Also, there is a substantial body of research by scholars such as Robert Crandall at Brookings, McKibben and Wilcoxin, Yale professor Bill Nordhaus, that suggest that the cost of going ahead with sharp, near-term caps on emissions far exceed the benefits, even when you take account of the possibility of some changes to climate.

So I think the evidence suggests we need to take a cautious attitude before deciding what is the best strategy to address the potential threat of climate change, and I do not think the scholars whose work I am mentioning suggest that nothing needs to be done. Clearly it does, but we need to move forward in the most efficient, cost-effective possible way, so as not unduly burden the U.S. economy and our trading partners.

I would like to make a few comments about S. 1008. I think Senators Byrd and Stevens are to be commended for their recognition of the importance of technological innovation as the principal means of dealing with the possible threat, potential threat, of climate change. S. 1008 contains some helpful initiatives that could

[1] The prepared statement of Ms. Thorning appears in the Appendix on page 98.

further the goals of maintaining strong economic growth and energy security, while reducing greenhouse gas emissions. The bill also appears to be supportive of some of the initiatives put forth by the Bush Administration, including advancing clean-coal technology.

I was very pleased to hear the other comments about the importance of coal to the U.S. economy. It is clearly going to be a major energy source for the foreseeable future, and we do need to accelerate the development of clean-coal technology. However, I would like to suggest that S. 1008 falls short in some ways, in terms of promoting many of the policies I suggested in my testimony for encouraging technological innovation.

For example, S. 1008 does not address the question of how to deploy new technology. We need to develop it, but how do we get it adopted? How do we get it into the system? One thing I would like to draw your attention to is the U.S. Tax Code, which taxes new investment much more harshly than most of our competitors, whether it is productive investment or whether it is pollution-control investment. As Table 1 of my testimony shows, the United States has very slow capital cost recovery. We rank near the bottom of a list of eight countries that Arthur Andersen surveyed. If we could improve depreciation or tax incentives for pulling through, it would help to pull through the kinds of equipment that would enable us to both grow and reduce CO_2 emissions.

So, taking a look at the tax code and, as the Bush Administration moves forward with tax reform, hopefully that would be part of hopefully better depreciation, particularly for energy-efficient or pollution-reduction—would be part of any tax code reform. Second, S. 1008 does not address nuclear power. That has clearly got to be a major component, at least over the next several decades, of U.S. energy supply; France manages to produce 80 percent of its electricity and the United States only 20 percent. So it suggests that we ought to be able to move forward to rely on a source of energy that is much less polluting.

We also need more bilateral cooperation with developing countries to promote the use of existing and emerging technology. We need to expand incentives for landfill methane and biomass, the EIA Clean Technology Initiative report shows that those were the two most effective programs, and I do not believe S. 1008 addresses those. Finally, we need to avoid caps on CO_2 emissions by U.S. industry and avoid setting targets at this time. We need further study of this issue. We need to move forward, but in a cost-effective, careful way.

Thank you, Mr. Chairman.

Chairman LIEBERMAN. Thank you very much. Thanks for your testimony. I appreciate the effort that all of you put into appearing before us.

Ms. Claussen, let me start with you, and you talked about the critical need for a national strategy on climate change. You have extensive experience in government. Now you are in the private sector, working with some of America's largest corporations. Just give us your reaction to what you think the impact would be of a central White House office focused on climate change, and I want to ask the question implicitly, is it worth it? In other words, we do

not want to continue to proliferate offices in the White House, but how do you see it here?

Ms. CLAUSSEN. Senator, I was in government for about 25 years, and I participated in interagency process in the Reagan Administration and the first Bush Administration. In the early part of the Clinton Administration, I actually ran an interagency process. I hope I learned from the first two administrations and applied some of it in the third, but the fact is, this is a monster of an issue and everyone has a legitimate reason to be involved across the government for a variety of different reasons. If you do not have a way to focus the effort and coordinate the effort, you just have everybody doing their own thing based on their own set of objectives and the culture of their own agency. You do not have a coherent policy. It is extremely hard to do, but I think you have to center it in the White House and you have to put some real effort into making it work.

Chairman LIEBERMAN. Thank you. Let me go now to the economic consequences and, in a sense, some of the questions that Senator Bennett raised about the costs of complying with Kyoto or the cost of responding to the climate change problem. I was interested that, I think, Dr. Edmonds and Mr. Lash, in your prepared testimony, talked about the economic consequences of inaction here. I wonder if you could both expand on that, and if there is any way in which we could begin to quantify the economic cost of inaction.

Mr. EDMONDS. Thank you, Mr. Chairman. The Global Energy Technology Strategy Program has shown that cost does matter and is an important element that must be taken into account in framing an effective response to climate change. The climate change issue is essentially an intergenerational problem. This makes the climate change problem far more difficult than local environmental problems involving short-lived gases and aerosols, with which we are more familiar.

We largely live with the climate that we inherited from our predecessors, while we are in turn laying down the foundations of the climate that we will pass on to the next generation. But, we have very little margin to change our own climate. The actions that we take to mitigate emissions are therefore largely undertaken out of an altruistic motivation-care for our children and grandchildren. Under such circumstances the cost of emissions mitigation matters a great deal.

This observation in turn leads us back to the importance of developing technologies and energy systems that can limit emissions in a cost-effective manner. And, that is the heart of S. 1008. Without cost-effective energy technologies and systems even the best-crafted tactics to limit cumulative global emissions of carbon to the atmosphere will ultimately prove to be either too expensive to implement, or will more likely lead to higher concentrations and greater climate change for future generations.

On the other hand, if energy technologies and systems are developed and made available at reasonable cost, all tactics for controlling emissions begin to look much more attractive, as do lower cumulative global carbon emissions and long-term CO_2 concentrations.

I think the thrust of everything we have learned under this global energy technology strategy program is that cost does matter. It is a very important element. It has to be taken into account. The climate change issue is essentially an intergenerational problem, and we largely live with the climate that we inherited from our predecessors, and we lay down the concentrations of greenhouse gases in the atmosphere that are passed onto the next generation. So, in fact, most of our margin is not on our own climate. It is an altruistic enterprise, and under those circumstances, we do altruism. We save for our kids education and we do things for the future, but cost really does matter and it matters a lot.

I think what comes out of this global energy technology strategy program is that addressing the climate change issue seriously requires that we deal with this as a century scale problem, not as a year by year problem, and that if the technology to address climate change is not available—that is the core of what S. 1008 is about—if it is not available, pretty much independent of the best crafted tactics to limit cumulative global emissions of carbon to the atmosphere are ultimately going to turn out to be too expensive, and we will either not do it or we will not do as much as we could.

On the other hand, if the technology is developed and is made available, all the tactics begin to look much more attractive and it is a lot easier to do the job right. I think that is the important lesson, that if we have the technology, it is going to be a lot easier job and costs are going to be minimal.

Chairman LIEBERMAN. Mr. Lash.

Mr. LASH. Two brief comments—first, looking at the costs of action, one gets very different answers depending on the assumptions used in the models that do the calculations and on the policies that one analyzes. If the models assume that the economy is very good at changing sources of fuel, that we would use more gas and less coal as a response, and that new technologies would develop, the cost is low. If the models do not assume that kind of flexibility in our economy, the cost is high. If the models account for benefits, the cost is low. If the models do not account for benefits, the cost is high. Most models do not account for benefits because to account for benefits is very difficult.

For instance, Dr. Hansen was talking about the number of people who die from air pollution who might be saved if we reduce pollution. Certainly, it is very important what policies are used. If you have a rigid regulatory system that imposes huge and sudden cost on utilities or on the auto industry, reductions will cost a lot. If you have a market-based system that allows companies to choose how they are going to proceed over a number of years, reductions will cost less. It is important to make those distinctions as one is analyzing costs. The same is true for the benefits of action and the costs of inaction. Because we are uncertain about precisely what will happen 25 years from now if we do not take action—any assessment we make of those costs is going to involve the kinds of scenarios that Dr. Hansen was talking about, and guesses about impacts, both here and externally, and it makes counting them difficult. The assumptions going in determine the numbers coming out.

Chairman LIEBERMAN. Mr. Heydlauff, it might be interesting to ask you to comment on this from the perspective of one company, a big, significant company, America's largest generator of electricity, generating about 6 percent of the U.S. figure, comparable to the annual electric power consumption of Mexico and Australia. I am just reading from your testimony—6.1 million customers. So the question is, from your company's point of view, you are supporting action here, I assume, as an act of good citizenship, but also because there has been a calculation made within the company and you dispatched your responsibility to shareholders that this is the right way to go economically, as well. I wonder if you could talk about that a little bit.

Mr. HEYDLAUFF. I would be happy to do that. One thing I believe has come out of the research that we help fund, is that you cannot solve this problem without new technology. We believe as a company that it would be a shame if the country adds new generation, utilizing existing technologies, and does not take advantage of advanced, more efficient, less carbon intensive technologies to meet the energy needs of the Nation, and most importantly, then, if we also do not take that technology and deploy it around the globe. Let me give you a concrete example of where I think the challenge is greatest, and that is in the developing nations, which are going to utilize their indigenous energy resources to grow their economies. Case in point is China.

China's total coal burned in 1996, I think, was 600 million or 700 million tons a year. They are projected to burn 2.1 billion tons a year by 2015, the year at which they are also projected to have their greenhouse gas emissions equal those of the United States of America. A number of years ago, the Chinese came to us recognizing our expertise in coal-fired generation. They said we are going to build lots of new coal-fired generation, approximately at the time they were talking about building 15,000 megawatts of new generation a year, and we would like to talk to you about building some of those plants for us. We told them that, initially, our real interest was in trying to take these innovative clean-coal technologies that are much more efficient and much cleaner and deploy them in China. The problem is there is a price premium for that, that neither we nor our shareholders were willing to eat, nor were the Chinese willing to pay. That is one of the reasons why, for a number of years, Senator Byrd has had legislation in saying we need to figure a way to subsidize that delta between conventional technology and innovative technologies.

We built a power plant in China, relatively clean, but it was utilizing 1940's, 1950's technology because that is all they were willing to pay for. I felt real bad about it, honestly, until I understood what we were displacing, which was the direct use of coal to heat and cook in residential dwellings. We brought electricity to a community that never had it before, which is obviously far cleaner and more efficient than what they were doing. But it was not what we should have accomplished, which was that leapfrog in technology use internationally. I do not believe AEP will build another coal-fired power plant like we have in operation today. I believe it will be much more efficient. I think coal has been the bedrock fuel for

electric generation in this country for 100 years, and it will continue to be.

We have got to find a way to burn it more efficiently, more cleanly—which the Byrd-Stevens legislation would accomplish. I applaud President Bush in his initiatives that he announced late last week, which is to advance research on carbon capture and then either utilizing the carbon dioxide for enhanced oil and gas recovery, or more appropriately probably because the volumes will be so significant, disposing of it in a safe and permanent manner in geologic formations; deep saline aquifers, abandoned oil and gas wells, coal mines, whatever. That is how you keep coal in the fuel mix, which I think is essential.

Chairman LIEBERMAN. I am going to yield to Senator Thompson and maybe he wants to take up this line of questioning. I take it from what you said in your earlier testimony that notwithstanding the need for transformational new technologies, energy technologies, you do not see the private sector here investing the necessary money in research and development, which is why we need the kind of focused, expanded effort that is part of this research and development effort through the Federal Government that is part of the Byrd-Stevens bill.

Mr. HEYDLAUFF. That is correct. Certainly, history would suggest that the levels of private sector investment in those revolutionary bold breakthrough technologies is pretty much nonexistent. There is very little of it going on today, and perhaps this legislation will motivate that.

Chairman LIEBERMAN. Thanks, thanks very much. Senator Thompson?

Senator THOMPSON. I wonder why the R&D has been so low in this area, compared to other industries. It looks to me like you are being besieged at all sides. I know you and I share a commonality in that we both represent entities that are being sued by EPA right now. I am referring to TVA, saying that we are keeping the old plants on too long, and the modifications are not permitted under the Clean Air Act. So, in fact, it is a mini-Kyoto situation, it looks to me like. You have the factor of your need for a global approach to it, because the pollution in the area is destroying the Smoky Mountains National Park, by the way. You have automobile emissions and the coal emissions from the TVA plants, but a lot of it comes from your part of the country and it settles right down in that area.

No company or entity wants to be disadvantaged. So you are going to have to have a global solution, more or less. The costs are said to be astronomical if we do it any differently. The rates will go up in the TVA area if we correct the problem and nobody knows really how much, but the damage being done is clearer there. It is more imminent. It is more polluted on the top of the Smoky Mountains most days than it is on the streets of New York City. So if we cannot have some kind of regional solution to that, I am wondering how we are going to take on the world.

I get back to my point. I wonder why, with all this pressure and commentary, industry is not doing more. Clearly the government needs to step into this. That is what we do best up here. We mandate all these different things, all these different entities, and we

come to what seem to be logical conclusions about what ought to be done about all of these problems. We pass some bills not knowing what we are doing, unintended consequences run rampant. This is what we do well up here, research and development, but industry, I think, has got to do more too.

I would like to work with you some in the future and talk about some way we can approach this regional problem that is doing a lot of damage. Nobody wants to put anybody at a competitive disadvantage, but maybe if we do it together——

Mr. HEYDLAUFF. Just to respond very quickly, one of the other things that Congress can do and can do well is resolve conflicts in Federal policy. Nowhere is that more in evidence than in the issue that you raised about new source review. The Clinton Administration came to us early on and said they were going to meet the aim of the framework convention on climate change to reduce emissions levels by the year 2000, but they do not want to rely on new bureaucracies and new regulations. They want to tap the ingenuity of the American public, and in particular, American industry.

The electric utility industry stepped up to the plate and put together a very robust program of response measures. We literally combed our company for opportunities to improve the efficiency with which we convert coal into electrons, and we took a number of measures at our power plants to do that. I would submit to you that everything we did that improved the efficiency with which we converted energy into electrons, simultaneously reduced those air emissions that you are concerned about in the Smoky Mountains. Yet, we are in the unhappy position today of having been sued for taking some of those actions. We are improving the efficiency of the plant, we are reducing emissions, yet the government is telling us that was a violation of new source review rules and, consequently and unfortunately, we have halted those measures until we have resolved this issue.

I hope that—and I realize that is an issue not for this Committee. Senator Lieberman, it is for your other committee, and in that we can get that issue resolved too. View it in the context of a multi-pollutant control legislation that Senator Voinovich talked about, where we can bring a rational approach, a resolution to all of these issues; the air quality issues, Senator Thompson, that you are concerned about in Tennessee, and I know they are concerned about it in the Northeast, as well as, perhaps, starting down the path that we all hope to go down in terms of the response to global climate change concerns.

Senator THOMPSON. Going to another question here that was mentioned, I think that several members of the panel, specifically Mr. Lash, mentioned the uncertainty of the economic estimates. I saw a June 12 *USA Today* article, I think you referenced it in your testimony, Ms. Thorning, that indicates the Clinton Administration has now acknowledged that its economic analysis was flawed. Back during Kyoto, they came up with some rather low numbers as to what it would cost—but, it seems it was based on China and India accepting binding emissions limits, which they have not, and Europe and other countries engaging in emissions trading as a solution, and apparently they are not making any progress on that. Former administration officials were quoted as saying, "That the

thing that made them really uneasy about our analysis was that if our assumptions do not come true, costs can come up much, much higher."

Ms. Thorning, you have done that, I know, in some of your work. It has been pointed out that it is very uncertain and it all depends on assumptions and so forth. I would like for you to address that and I would specifically like for you to address what we should do and how much is it going to cost? Kyoto is a good place to start. That is one so-called solution that is out there, and people can try to measure it. There are, obviously, other approaches that will presumably have lower price tags. As far as Kyoto is concerned, first discuss the validity of being able to analyze the economic aspects. Second, what does your work reveal in terms of the effect it would have on: The gross domestic product of this country; our growth, on gas and electricity prices; and on migration of industry out of this country?

Ms. THORNING. Thank you, Senator Thompson. The focus of our work over the past 10 years at the ACCF—and we have spent a fair amount of time on the issue of climate change—has been looking at the costs of action, and what are appropriate policies to respond to this potential threat. A range of credible modelers, ranging from the Department of Energy to Wharton Econometric Forecasting Associates, Australian Bureau of Resource Economics, Charles Rivers Associates, Professor Alan Mann at Stanford, suggest that the cost range of complying with Kyoto would be 2 to 4 percent of U.S. GDP or $200 to $400 billion a year. Of course, the cost varies depending on what the assumption is about global trading, particularly, as well as some other variables in the models.

As you mentioned, the Clinton Administration's Council of Economic Advisers number was really off the chart, which they have now admitted was erroneous. So it seems to me very clear that the costs are high. The Department of Energy also estimated that electricity prices would have to rise perhaps as much as 80 percent, gasoline prices, 50 percent. So the cost to the American economy is very significant. Low-income wage earners would be particularly disproportionately impacted, because the cost of energy is a much larger share of their budget. U.S. industry would tend to migrate to countries that were not CO_2 constrained. Alan Mann's work suggests that by 2020, we might lose 10 to 15 percent of our energy intensive sector. So there are very serious consequences to precipitously moving forward to limit—cap CO_2 emissions. It seems to me that given the uncertainty about the science, the focus of your hearing today, which is on the importance of technology and the development of alternative technologies for energy production, is very appropriate. We do need to focus on that.

Senator THOMPSON. Without China and India and these other countries being a part of it, would the CO_2 emissions continue to rise anyway?

Ms. THORNING. They will continue to rise. There are numerous projections that show that even if the United States and Europe shut down and sat in the dark—no electricity, no cars—the impact on global concentrations of CO_2 would be almost negligible.

Senator THOMPSON. Do you have any basis for reaching an opinion as to whether or not the European Union could or would comply, even if we did?

Ms. THORNING. As my testimony points out, there are five or six new studies that suggest that the European Union will be 15 to 25 percent above its emissions targets by 2010 or 2012. So it is hypocritical, really, of the European Union to rail against the Bush Administration's policy of stepping back and taking another look at how to address climate change.

Senator THOMPSON. It seems to me that the European Union's attitude toward Kyoto is somewhat like some of our Democratic friends'—on the House side—attitude is toward campaign finance reform, and that is it is a great idea, as long as it does not happen. [Laughter.]

Ms. THORNING. One of the things that I think people need to realize about the European Union is the leaders there have 10 years worth of capital built up, political capital. They have made the case that they need to comply with Kyoto and it is very difficult for them now to simply back away, I think, and we need to be sensitive to that situation and help—which I think the Bush Administration is trying to do—come up with alternative strategies that will enable them to feel that we and the rest of the world are going to move forward.

Senator THOMPSON. Thank you, Mr. Chairman.

Chairman LIEBERMAN. Thanks, Senator Thompson. It strikes me you are one of a small, courageous band of Republicans that could have made that comment about Democrats and campaign finance reform. [Laughter.]

Senator Bennett.

Senator BENNETT. Thank you, Mr. Chairman. I could not possibly have said what Senator Thompson said on that score. As I sit through the morning, I am beginning to see the emergence of consensus, and let me try it out and see if you agree, because obviously I do not want to put words in anybody's mouth. But it seems to me that technology is the answer to this problem. Arbitrary limits, such as came out of the Kyoto Protocol, are not, but technology that is developed to be more efficient almost always means cleaner, and there are economic benefits to being more efficient, and cleaner is a wonderful side effect that comes out, and indeed, as Mr. Lash points out, has some economic benefit in and of itself.

I am referring to an editorial comment made by Robert Samuelson, and I liked his opening. He said, "The education of George W. Bush on global warming as simply summarized: Honesty may not be the best policy." Greenhouse politics have long blended exaggeration and deception, and the Bush Administration, I think, has told the truth about Kyoto and now is being beaten up for it. But that is not the issue. The issue is what do we do, and the answer seems to be, coming out of today's hearing, that we develop the technology to deal with it, rather than putting on the artificial, politically-dominated caps.

Now, you are shaking your head, Ms. Claussen. You take the first shot at me here.

Ms. CLAUSSEN. I agree with I think virtually everyone on this panel that you cannot solve this without technology. But I do not

think that precludes the need for rational, sensible limits, which I think can also help you move the technology on the development side and also on the deployment side. This is not to say you need a mandatory system that will bankrupt the economy or that will move too soon, too much, but I think there is a real place for limits which, if done rationally over time and in a way that the market can sort out, have to be a part of the system.

Senator BENNETT. Let me give you an analogy then. You used two words, neither one of which can be challenged, but that create great mischief up here: Rational and sensible. I am not sure we are ever complying with both of those in legislation that we pass.

Ms. CLAUSSEN. Well, I have great faith in the Senate.

Senator BENNETT. But in the automobile industry, CAFE standards have no doubt produced technological breakthroughs. I was at the Department of Transportation when the catalytic converter was introduced, and that was a technological breakthrough. But it was driven in part by CAFE standards. One of the interesting side effects of CAFE standards has been the creation of the automobile industry in Japan, because the Americans, for whatever reason, did not seem to be able to produce reliable small cars, and so more and more people started importing cars from Japan, where they had the technology to produce these kinds of cars. That is a separate debate.

In the Samuelson column, he talks about how Europe has achieved what they have achieved with respect to emissions. He says there are only three countries in Europe that have reduced their emissions: Germany, Britain, and Luxembourg. I do not think we need to worry about Luxembourg. Britain, because of plentiful North Sea gas, they have shifted from coal. But in Germany, it is a one-time experience, as they have shut down the technologically-impaired plants of East Germany that came in with unification, and once that is done, they are not going to get another boost, unless there are technological breakthroughs that can say, when the time comes to retrofit a plant, we are going to retrofit it with one that is more efficient and cleaner. Along the lines, to stretch the analogy, of the CAFE standards, we are going to get rid of the Cadillac and buy a Toyota, and maybe we have to buy two Toyotas to carry everybody around, but maybe not, because you can really only get six people in a Cadillac, and if everybody breathes at the same time, you can get five in a Toyota.

So I am just reacting here, but the reason I am doing this is because I find in the environmental community some segments that are anti-technology. They hate the idea of technology. Now, the best example of that, and this is obviously pathological, was the Unabomber, who did everything he could to attack technology as the source of all of our problems, when, in fact, technology is the solution to our problems, and the people who are heavy in the rhetoric, anti-technology, need to realize that we all need to get on board in the same thing if we are going to solve this kind of problem.

Now let me give you an example, and maybe Mr. Heydlauff, you could comment on this. I talked to the electrical generators in Utah—obvious parochial interest. They tell me they are very bullish on wind. We have got a lot of wind in the West and they are

very bullish on wind, and they have been able to design the windmills in such a way that they are not particularly dangerous to birds anymore. But there is one problem with wind, and that is that the wind stops, and you cannot stockpile energy the way you can stockpile Toyotas, and when the wind stops, you have got to have some alternative.

The obvious alternative is hydro, where you have a body of water stored, and when the wind stops, you allow that water to go through the turbine and generate electricity until the wind starts again, and then, in those hours of the night when nobody is using the wind energy and you have excess capacity, you pump the water back up. To me, this is an obvious, wonderful solution to changing, and many in the environmental community say we are opposed to hydro in any way, shape or form.

This is a technological solution that can help us, that is being attacked for ideological political reasons. Does anybody have a comment on technology? You have taken me on, and I accept your——

Mr. LASH. Can we disavow the Unabomber first?

Senator BENNETT. Yes, let's all disavow the Unabomber.

Chairman LIEBERMAN. We environmentalists do not want Mr. Kaczynski to be our representative here.

Mr. HEYDLAUFF. Senator, one of the strengths of the U.S. economy, I think, is the fact that we power it with a wide diversity of energy sources. Coal is approximately 50 percent of the electricity base. We have got 21 percent, I think, roughly is the nuclear capacity. Natural gas is approximately 15 percent; hydro is 10 percent; a little bit of oil and the balance is going to be these non-renewable resources you talked about, which is less than 2 percent. I think we need them all and I think we need to develop them all, and we need to develop them in a way that is both economically rational, but also protective of the environment, more so than we ever have in the past.

We are a diversified energy company. I talked about the fact that we burn, I think as Jonathan said, nearly 80 million tons of coal a year, but that is only 66 percent of our generation mix; 24 percent is natural gas. We do have nuclear generation, hydro, and we are about to commission a 150 megawatt wind plant, which we are very proud of. It is in Texas, and we think there is a lot of wind potential in Texas. You are absolutely right about the intermittent nature of wind generation, and it is going to be a problem that will keep a lot of these intermittent renewable energy resources, like solar and wind, at the periphery of the electricity supply business until such time as we have a dramatic breakthrough in energy storage technology, and that has been elusive, as you know.

As a matter of fact, we would solve the urban smog problem in Senator Lieberman's State if we could just come up with an efficient energy storage system, so that people could drive around in the cars and electric vehicles that do not emit anything. But we are still going to have an urban smog problem for as far as we can see, because we have not found that, and the automobile manufacturers actually have cut back on a lot of that research and gone to hybrids instead. So that is a challenge, but it is growing and it will continue to grow and capture more of the energy market.

Frankly, I think—and we have got experience with this—the renewable energy systems make a lot of sense in developing countries, either in those areas where they have no access to electricity or in areas where their electricity comes from diesel generation. We, for example, have put in solar generation, photovoltaic systems, in Bolivia, and in one case it was to provide electricity for the first time to a community, and in the other case it is displacing diesel generation. We are looking at that. We are looking at, actually, renewable hybrids similar to what you talked about, small-scale hydro systems, combined with solar and wind generation.

So there are a lot of solutions, I think, to the energy challenges of the world, and certainly the country, that we need to continue to exploit. Your suggestions are correct and you are absolutely right, there are relatively entrenched opponents to virtually any form of electric generation. We certainly have it with coal. You see it with nuclear. You have it with hydro and we are well-aware of that. It is very difficult today to site and build a new hydro plant. As a matter of fact, I think we have pretty much developed all the economically feasible areas anyway. It is just hard to get them relicensed today.

Senator BENNETT. They are trying to tear them down in my State.

Mr. HEYDLAUFF. And they are trying to tear them down, I know, out West. Even the most efficient, clean natural gas generation, you are having a hard time siting and building in the Midwest, some States where you would not expect it, like in Indiana, where they have had enormous difficulty trying to site new natural gas power plants. We have the old NIMBY (not in my backyard) syndrome prevalent in ways that we have never had to deal with when we built the existing infrastructure. But that infrastructure needs to be replaced. It is getting old and we have got to replace it.

So we have to come up with a rational energy strategy, and I guess that is for another committee as well.

Senator BENNETT. Thank you. Let the record show that I am the only member of the Senate who drives a Honda Insight, get 55 miles to the gallon, and I bought it because I was in love with the technology.

Senator THOMPSON. How do you get in it, is the question?

Senator BENNETT. I have had you in it, the two of us.

Chairman LIEBERMAN. I have actually seen you get in and out of it, and it is an impressive sight, and quite comfortable. [Laughter.]

I would say to my friend from Utah—I thank him for his questions—I think he is right. There is a consensus here about the need for technology and bold new energy technologies to deal with the problem of climate change and air pollution and the rest. I think there is also an agreement, an important one, that, for various reasons, the private sector is not going to do it itself. So this is one where the government has, as Senator Thompson said, some credibility and needs to do it.

But the second part of this, about the private sector, and this is where we separate for the moment, anyway, is that I think, as Ms. Claussen does, that we need caps, and the best reason is actually the example you gave, of the CAFE standards, of the fuel mileage

standards, because what we do here does drive technology. In other words, if we create standards, the private sector will figure out ways often to meet them. As Ms. Claussen said, we have got to calibrate this as best we can, because we do not want to create economic havoc, certainly, in the short run.

The other reason that I favor the binding targets and timetables is that we had this experience in the 1990's after the Rio framework, which set targets and timetables and made them voluntary, and nobody did much of anything around the country and the world, and the problem got worse. So I think that is what actually led to Kyoto. One may disagree with the specifics of the Kyoto Protocol. I was actually in Kyoto, and it was a remarkable experience, watching all those countries with differing points of few, differing domestic political constituencies and energy resources, trying to work something out.

So it is far from perfect and it is always subject to alteration, but I think that is a point at which we differ. The good thing about the Byrd-Stevens is it does not require us to reach consensus on those questions. It creates these mechanisms, these offices in the Federal Government, that will stimulate and finance more research and development, that will force us to come back at this every year and see how we are doing and create a strategy that reaches toward stabilization.

I come to the end of the hearing, thanking all the witnesses and my colleagues, feeling that though there are still disagreements about tactics here, that this bill really does provide us with some common ground to go forward, and in doing that, I do think it is a breakthrough.

Senator Thompson, if you want to add anything——

Senator THOMPSON. Well said, Mr. Chairman.

Chairman LIEBERMAN. Thank you, all. The hearing is adjourned.

[Whereupon, the 12:26 p.m., the Committee was adjourned.]

APPENDIX

Hold for Release
Until Presented by Witness
July 18, 2001

Statement of

Dr. James E. Hansen
Head
NASA Goddard Institute for Space Studies

before the

Committee on Governmental Affairs
United States Senate

1. Preface.

Mr. Chairman and Members of the Committee:

I appreciate the opportunity to provide information relevant to your considerations of a strategy to address climate change. Specifically, I would like to clarify and expand upon a paper that I co-authored with four other scientists on climate change in the 21st century, published in Proceedings of the National Academy of Sciences (1). In that paper, we define an "alternative scenario" for the forcing agents that cause climate change. The alternative scenario gives equal emphasis to reducing air pollution and to a continued slow downtrend in CO_2 emissions. This scenario produces only a moderate climate change in the next 50 years. We suggest that the climate forcings in this scenario can be achieved via pragmatic actions that make good sense for a variety of reasons. Collateral benefits include improvements in human health, agricultural productivity, and greater energy self-sufficiency. Our alternative scenario differs markedly from the "business as usual" scenarios of the Intergovernmental Panel on Climate Change (IPCC), which have received the greatest attention among the plethora of IPCC scenarios. However, I emphasize that our paper is not a criticism of IPCC. The IPCC reports (2), produced by hundreds of outstanding scientists, provide an invaluable assessment of the status of scientific understanding of climate change.

Although our research has relevance to public issues, including your present consideration of strategies for long-term stabilization of climate forcings, it is not our job to suggest policies. Our objective is to provide scientific information that the public and their representatives can use to help choose wise policies. Thus our aim is to provide relevant information on the forcing agents that drive climate change that is as quantitative and as clear as the data permit.

2. Introduction: Basic Concepts.

The Earth's climate fluctuates from year to year and century to century, just as the weather fluctuates from day to day. It is a chaotic system, so changes occur without any forcing, but the chaotic changes are limited in magnitude. The climate also responds to forcings. If the sun brightens, a natural forcing, the Earth becomes warmer. If a large volcano spews aerosols into the stratosphere, these small particles reflect sunlight away and the Earth tends to cool. There are also human-made forcings.

We measure forcings in watts per square meter (W/m^2). For example, all the human-made greenhouse gases now cause a forcing of more than 2 W/m^2. It is as if we have placed two miniature Christmas tree bulbs over every square meter of the Earth's surface. That is equivalent to increasing the brightness of the sun by about 1 percent.

We understand reasonably well how sensitive the Earth's climate is to a forcing. Our most reliable measure comes from the history of the Earth. We can compare the current warm period, which has existed several thousand years, to the previous ice age, about 20,000 years ago (3, 4, 5). We know the composition of the atmosphere during the ice age from bubbles of air that were trapped as the ice sheets on Greenland and Antarctica built up from snowfall. There was less carbon dioxide (CO_2) and less methane (CH_4), but more dust in the air. The surface was different then, with ice sheets covering Canada and parts of Europe, different distributions of vegetation, even the coast-lines differed because sea level was about 400 feet lower. These changes, as summarized in Figure 1, caused a negative climate forcing of about 6½ W/m^2. That forcing maintained a planet that was 5°C colder than today. This empirical information implies that climate sensitivity is about ¾°C per W/m^2 of forcing. Climate models have about the same sensitivity, which provides encouraging agreement between the real world and the complex computer models that we use to predict how climate may change in the future.

There is another important concept to understand. The climate cannot respond immediately to a forcing, because of the long time needed to warm the ocean. It takes a few decades to achieve just half of the equilibrium climate response to a forcing. Even in 100 years the response may be only 60-90 percent complete (5). This long response time complicates the problem for policy-makers. It means that we can put into the pipeline climate change that will only emerge during the lives of our children and grandchildren. Therefore we must be alert to detect and understand climate change early on, so that the most appropriate policies can be adopted.

3. Past Climate Forcings and Climate Change.

The climate forcings that exist today are summarized in Figure 2 (1, 6). The greenhouse gases, on the left, have a positive forcing, which would tend to cause warming. CO_2 has the largest forcing, but CH_4, when its indirect effect on other gases is included, causes a forcing half as large as that of CO_2. CO_2 is likely to be increasingly dominant in the future, but the other forcings are not negligible.

Aerosols, in the middle of the figure, are fine particles in the air. Some of these, such as sulfate, which comes from the sulfur released in coal and oil burning, are white, so they scatter sunlight and cause a cooling. Black carbon (soot) is a product of incomplete combustion, especially of diesel fuel and coal. Soot absorbs sunlight and thus warms the planet. Aerosols tend to increase the number of cloud droplets, thus making the clouds brighter and longer-lived. All of the aerosol effects have large uncertainty bars, because our measurements are inadequate and our understanding of aerosol processes is limited.

If we accepted these estimates at face value, despite their large uncertainties, we would conclude that, climate forcing has increased by 1.6 W/m^2 since the Industrial Revolution began [the error bars, in some cases subjective, yield an uncertainty in the net forcing of 1 W/m^2]. The equilibrium warming from a forcing of 1.6 W/m^2 is 1.2°C. However, because of the ocean's long response time, we would expect a global warming to date of only about ¾°C. An energy imbalance of 0.6 W/m^2 remains, with that much more energy coming into the planet than going out. This means there is another ½°C global warming already in the pipeline - it will occur even if atmospheric composition remains fixed at today's values.

The climate forcings are known more precisely for the past 50 years, especially during the past 25 years of satellite measurements. Our best estimates are shown in Figure 3. The history of the tropospheric aerosol forcing, which involves partial cancellation of positive and negative forcings, is uncertain because of the absence of measurements. However, the GHG and stratospheric aerosol forcings, which are large forcings during this period, are known accurately.

When we use these forcings in a global climate model (3) to calculate the climate change (6), the results are consistent with observations (Figure 4). We make five model runs, because of the chaos in the climate system. The red curve is the average of the five runs. The black dots are observations. The Earth's stratosphere cools as a result of ozone depletion and CO_2 increase, but it warms after volcanic eruptions. The troposphere and the surface warm because of the predominantly positive forcing by increases of greenhouse gases, in reasonably good agreement with observations.

The fourth panel in Figure 4 is important. It shows that the simulated planet has an increasing energy imbalance with space. There is more energy coming into the planet, from the sun, than there is energy going out. The calculated imbalance today is about 0.6 W/m^2. This, as mentioned above, implies that there is about 0.5°C additional global warming already in the pipeline, even if the atmospheric composition does not change further. An important confirmation of this energy imbalance has occurred recently with the discovery that the deep ocean is warming. That study (7) shows that the ocean took up heat at an average rate of 0.3 W/m^2 during the past 50 years, which is reasonably consistent with the predictions from climate models. Observed global sea ice cover has also decreased as the models predict.

There are many sources of uncertainty in the climate simulations and their interpretation. Principal among the uncertainties are climate sensitivity (the Goddard Institute for Space Studies model sensitivity is 3°C for doubled CO_2, but actual sensitivity could be as small as 2°C or as large as 4°C for doubled CO_2), the climate forcing scenario (aerosols and tropospheric ozone changes are very poorly measured), and the simulated heat storage in the ocean (which depends upon the realism of the ocean circulation and mixing). It is possible to find other combinations of these "parameters" that yield satisfactory agreement with observed climate change. Nevertheless, the observed positive heat storage in the ocean is consistent with and provides some confirmation of the estimated climate forcing of 1.6 ± 1 W/m^2. Because these parameters in our model are obtained from first principles and are consistent with our understanding of the real world, we believe that it is meaningful to extend the simulations into the future, as we do in the following section. Such projections will become more reliable and precise in the future if we obtain better measurements and understanding of the climate forcings, more accurate and complete measures of climate change, especially heat storage in the ocean, and as we employ more realistic climate models, especially of ocean circulation and the upper atmosphere.

4. Scenarios for 2000-2050.

We extend our climate model simulations into the future for two climate forcing scenarios shown in Figure 5. In the popular "business-as-usual" scenario, which the media focuses upon, the climate forcing increases by almost 3 W/m^2 in the next 50 years. This leads to additional global warming of about 1.5°C by 2050 and several degrees by 2100. Such a scenario, with exponential growth of the greenhouse forcing, leads to predictions of dramatic climate change and serious impacts on society.

The "alternative scenario" assumes that global use of fossil fuels will continue at about today's rate, with an increase of 75 ppm in airborne CO_2 by 2050. Depending on the rate of CO_2 uptake by the ocean and biosphere this may require a small downtrend in CO_2 emissions, which would be a helpful trend for obtaining stabilization of greenhouse gases later in the century. The alternative scenario also assumes that there will be no net growth of the other forcings: in somewhat over-simplified terminology, "air

pollution" is not allowed to get any worse that it is today. The added climate forcing in the alternative scenario is just over 1 W/m^2 in the next 50 years.

The alternative scenario results in an additional global warming in the next 50 years of about ¾°C, much less than for the business-as-usual scenario. In addition, the rate of stratospheric cooling declines in the alternative scenario (top panel of Figure 5), and in fact the lower stratospheric temperature would probably level out because of expected stratospheric ozone recovery (not included in this simulation). The planetary energy imbalance increases by only about ¼ W/m^2 in the alternative scenario, compared with almost 1 W/m^2 in the business-as-usual scenario. In other words, our children will leave their children a debt (¾°C additional warming in the pipeline) that is only slightly more than the amount of unrealized warming (½°C) hanging over our heads now.

Figure 6 is a cartoon summarizing the two parts of the alternative scenario. First, the scenario keeps the added CO_2 forcing at about 1 W/m^2, which requires that annual increases in atmospheric CO_2 concentrations be similar to those in the past decade. The precise scenario that we employ has the CO_2 growth rate declining slowly during these 50 years, thus making it more feasible to achieve still lower growth rates in the second half of the century and an eventual "soft landing" for climate change. Second, the net growth of other climate forcings is assumed to cease. The most important of these "other" forcings are methane, tropospheric ozone, and black carbon aerosols. Specific trace gas scenarios used in our global climate model simulations are shown in Figure 7.

In the following two sections we provide data that helps provide an indication of how difficult or easy it may be to achieve the elements of the alternative scenario.

5. Alternative Scenario: Air Pollution.

One of the two requirements for achieving the alternative scenario is to stop the growth of non-CO_2 forcings. Principally, that means to halt, or even better reverse, the growth of black carbon (soot), tropospheric ozone (O_3) and methane (CH_4). These can loosely be described as air pollution, although in dilute amounts methane is not harmful to health. Black carbon, with absorbed organic carbon, nitrates and sulfates, and tropospheric ozone are principal ingredients in air pollution.

Black carbon (soot). Black carbon aerosols, except in the extreme case of exhaust puffs from very dirty diesel trucks or buses, are invisibly small particles. They are like tiny sponges that soak up toxic organic material that is also a product of fossil fuel combustion. The aerosols are so small that they penetrate human tissue deeply when breathed into the lungs, and some of the tiniest particles enter the blood stream. Particulate air pollution, including black carbon aerosol, has been increasingly implicated in respiratory and cardiac problems. A recent study in Europe (8) estimated that air pollution caused annually 40,000 deaths, 25,000 new cases of chronic bronchitis, 290,000 episodes of bronchitis in children, and 500,000 asthma attacks in France, Switzerland and Austria alone, with a net cost from the human health impacts equal to 1.6 percent of their gross domestic product. Pollution levels and health effects in the United States are at a comparable level. Primary sources of black carbon in the West are diesel fuels and coal burning.

The human costs of particulate air pollution in the developing world are staggering. A study recently published (9) concluded that about 270,000 children in India under the age of five die per year from acute respiratory infections arising from particulate air pollution. In this case the air pollution is caused mainly by low temperature inefficient burning of field residue, cow dung, biomass and coal within households for the purpose of cooking and heating. Pollution levels in China are comparably bad, but in China residential coal use is the largest source, followed by residential use of biofuels (10).

Referring back to Figure 2, note that there are several aerosols that cause cooling, in addition to black carbon that causes warming. There are ongoing efforts to slow the growth of sulfur emissions or reduce emissions absolutely, for the purpose of reducing acid rain. In our alternative scenario for climate forcings, it is assumed that any reduced sulfate cooling will be at least matched by reduced black carbon heating. Principal opportunities in the West are for cleaner more efficient diesel motors, cleaner more efficient coal burning at utilities, and substitution of alternative energy sources that produce less or no black carbon. Opportunities in the developing world include use of biogas in place of solid fuels for household use, and eventually use of electrical energy produced at central power plants.

Ozone (O_3). Chemical emissions that lead to tropospheric ozone formation are volatile organic compounds and nitrogen oxides (carbon monoxide and methane also contribute). Primary sources of these chemicals are transportation vehicles, power plants and industrial processes.

High levels of ozone have adverse health and ecosystem effects. Annual costs of the impacts on human health and crop productivity are each estimated to be on the order of $10 billion per year in the United States alone.

Ozone in the free troposphere can have a lifetime of weeks, and thus tropospheric ozone is at least a hemispheric if not a global problem. Emissions in Asia are projected to have a small effect on air quality in the United States (11). Closer neighbors can have larger effects, for example, recent ozone increases in Japan are thought to be due in large part to combustion products from China, Korea and Japan (12). A coordinated reduction of those chemical emissions that lead to the formation of low level ozone would be beneficial to developing and developed countries.

Our alternative scenario assumes that it will be possible, at minimum, to stop further growth of tropospheric ozone. Recent evidence suggests that tropospheric ozone is decreasing downwind of regions such as Western Europe (13), where nitrogen oxide and carbon monoxide emissions are now controlled, but increasing downwind of East Asia (12). Global warming may aggravate summer time ozone production, but this feedback effect would be reduced with the small warming in the alternative scenario. The evidence suggests that cleaner energy sources and improved combustion technology could achieve an overall ozone reduction.

Methane (CH_4). Methane today causes a climate forcing half as large as that of CO_2, if its indirect effects on stratospheric H_2O and tropospheric O_3 are included. The atmospheric lifetime of CH_4 is moderate, only 8-10, years, so if its sources were reduced, the atmospheric amount would decline rather quickly. Therefore it offers a great opportunity for a greenhouse gas success story. It would be possible to stabilize atmospheric CH_4 by reducing the sources by about 10%, and larger reductions could bring an absolute decrease of atmospheric CH_4 amount.

The primary natural source of methane is microbial decay of organic matter under anoxic conditions in wetlands. Anthropogenic sources, which in sum may be twice as great as the natural source, include rice cultivation, domestic ruminants, bacterial decay in landfills and sewage, leakage during the mining of fossil fuels, leakage from natural gas pipelines, and biomass burning.

There are a number of actions that could be taken to reduce CH_4 emissions: (1) capture of methane in coal mining, landfills, and waste management, (2) reduction of pipeline leakage, especially from antiquated systems such as in the former Soviet Union, (3) reduction of methane from ruminants and rice growing, as the farmers' objectives are to produce meat, milk and power from the animals, not methane, and food and fiber from the fields, not methane.

The economic benefits of such methane reductions are not so great that they are likely to happen automatically. Methane reduction probably requires international cooperation, including developing countries. Although the task is nontrivial, it represents an opportunity for a success story. In some sense, methane in climate change is analogous to the role of methyl-chloroform in ozone depletion. Although the growth of long-lived chlorofluorocarbons has only begun to flatten out, stratospheric chlorine is already declining in amount because of reductions in the sources of short-lived methyl-chloroform.

6. Alternative Scenario: Carbon Dioxide

CO_2 is the largest single human-made climate forcing agent today, and its proportion of the total human-made climate forcing can be anticipated to increase in the future. It is not practical to stop the growth of atmospheric CO_2 in the next several decades. However, it is possible to slow the growth rate of CO_2 emissions via actions that make good economic and strategic sense.

Scenarios for CO_2 are commonly constructed by making assumptions about population growth, standard of living increases, fuel choices, and technology. This procedure yields a huge range of possibilities with little guidance as to what is likely. An alternative approach is to examine historical and current rates of change of CO_2 emissions, estimate the changes that are needed to keep the climate change moderate, and consider actions that could produce such rates of change. That is the procedure we explore here.

Fossil-fuel CO_2 emissions. Figures 8 and 9 show U.S. and global CO_2 emissions. Emissions in the U.S. grew faster in the 1800s than in the rest of the world, as the U.S. itself was still growing and had rapid immigration. Growth of U.S. emissions was slower than in the rest of the world during the second half of the 20th century, when other parts of the world were industrializing.

The important period for the present discussion is the past 25 years, and the past decade. The U.S. growth rate was 1%/year over the past 25 years, as we largely succeeded in decoupling economic and energy use growth rates. The global growth rate was moderately higher, 1.4%, as there was faster growth in developing nations. However, in the past decade the growth rate of U.S. CO_2 emissions has been higher than in the world as a whole (1%/year in the U.S. vs. 0.6%/year in the world).

Figure 10 provides a useful summary. The U.S. portion of global fossil fuel CO_2 emissions increased from 10% in 1850 to 50% in 1920. Since then the U.S. portion has declined to 23% as other parts of the world industrialized. The temporary spike beginning in 1940 is associated with World War II, including vigorous exertion of U.S. industry to supply the war effort. In the 1990s the U.S. portion of global emissions increased.

Growth rate required for "alternative scenario". A small change in the CO_2 emissions growth rate yields large changes in emissions several decades in the future. A 1%/year growth yields a 64% growth of emissions in 50 years, compared with constant emissions (0%/year growth rate). A growth rate of -0.5%/year yields a -22% change of emissions in 50 years. Thus CO_2 emissions in 50 years are more than twice as large in a 1%/year scenario than in a -0.5%/year scenario.

Incomplete understanding of the Earth's "carbon cycle" creates some uncertainty, but to a good approximation the increase in atmospheric CO_2 is commensurate with the CO_2 emission rate. Therefore full achievement of the "alternative scenario" probably requires the global CO_2 emissions growth rate to be approximately zero or slightly negative over the next 50 years.

Even if the United States achieves a zero or slightly negative growth rate for CO_2 emissions, there is no guarantee that the rest of the world will follow suit. However, the economic and strategic advantages of a

more energy efficient economy are sufficient to make this path attractive to most countries. It is likely that the shape of the U.S. and global CO_2 emissions curves will continue to be fundamentally congruent. In any case, any strategy for achieving a climate change "soft landing", whether pursued unilaterally or otherwise, surely requires that the downward change in the U.S. CO_2 emission growth rate be at least comparable to the change needed in the global average. There are many reasons for the United States to aggressively pursue the technology needed to achieve reduced CO_2 emissions, including potential economic benefit and reduced dependence on foreign energy sources.

It is not our task to suggest specific policies. However, there are options for achieving the slower CO_2 growth rate. Otherwise, the alternative scenario is not viable.

In the short-term, a case can be made that pent-up slack in energy efficiency (14), if pursued aggressively, can help achieve a zero or slightly negative CO_2 emissions growth rate. Renewable energy sources, even though their output is relatively small, also can contribute to slowing the growth rate of emissions. There has been resistance of some industries to higher efficiency requirements. In that regard, the experience with chlorofluorocarbons is worth noting. Chemical manufacturers initially fought restrictions on CFC production, but once they changed their position and aggressively pursued alternatives they made more profits than ever. Similarly, if substantially improved efficiencies are developed (for air conditioners, appliances, etc.), such that there is a significant gap between operating costs of installed infrastructure and available technologies, that could facilitate increased turnover. Perhaps government or utility actions to encourage turnover also might be considered. Corporations will eventually reap large profits from clean air technologies, energy efficiency, and alternative energies, so it is important for our industry to establish a leadership position.

In the long-term, many energy analysts believe it is unlikely that energy efficiency and alternative energy sources can long sustain a global downtrend in CO_2 emissions. Lovins (15) argues otherwise, pointing out the cost competitiveness of efficient energy end-use, gas-fired cogeneration and trigeneration at diverse scales, wind power and other renewable sources. Certainly it makes sense to give priority to extracting the full potential from efficiency and renewable energy sources. Holdren (16) concludes that meeting the energy challenge requires that we maximize the capabilities and minimize the liabilities in the full array of energy options.

Many (my impression is, most) energy analysts believe that the requirement of a flat-to-downward trend of CO_2 emissions probably would require increasing penetration of a major energy source that produces little or no CO_2. Our task is only to argue that such possibilities exist. It will be up to the public, through their representatives, to weigh their benefits and liabilities. We mention three possibilities.

(1) *Nuclear power*: if its liabilities, including high cost and public concern about safety, waste disposal and nuclear weapons proliferation, can be overcome, it could provide a major no-CO_2 energy source. Advocates argue that a promising new generation of reactors is on the verge of overcoming these obstacles (17). There does not seem to be agreement on its potential cost competitiveness.

(2) *Clean coal*: improved energy efficiency and better scrubbing of particulate emissions present an argument for replacing old coal-fired power plants with modern designs. However, CO_2 emissions are still high, so an increasing long-term role for coal depends on development of the "zero emissions" plant, which involves CO_2 capture and sequestration (18).

(3) *Others*: Oppenheimer and Boyle (19) suggest that solar power, which contributes very little of our power at present, could become a significant contributor if it were used to generate hydrogen. The hydrogen can be used to generate electricity in a fuel cell. Of course the other energy sources can also be used to generate hydrogen.

In Holdren's (16) words: there are no silver bullets (in the array of energy options) nor are there any that we can be confident that we can do without. This suggests the need for balanced, increased public and private investment in research and development, including investments in generic technologies at the interface between energy supply and end use (20). The conclusion relevant to the alternative scenario is that, for the long-term, there are a number of possibilities for energy sources that produce no CO_2.

7. Benchmarks.

The alternative scenario sets a target (1 W/m^2 added climate forcing in 50 years) that is much more ambitious than IPCC business-as-usual scenarios. Achievement of this scenario requires halting the growth of non-CO_2 climate forcings and slightly declining CO_2 emissions. Climate change is a long-term issue and strategies surely must be adjusted as evidence accumulates and our understanding improves. For that purpose it will be important to have quantitative measures of the climate forcings.

Non-CO_2 forcings. The reason commonly given for not including O_3 and soot aerosols in the discussions about possible actions to slow climate change is the difficulty in quantifying their amounts and sources. That is a weak argument. These atmospheric constituents need to be measured in all countries for the sake of human health. The principal benchmark for these constituents would be their actual amounts. At the same time, we must develop improved understanding of all the sources of these gases and aerosols, which will help in devising the most cost-effective schemes for reducing the climate forcings and the health impacts.

Methane, with an atmospheric lifetime of several years, presents a case that is intermediate between short-lived air pollutants and CO_2. Measurements of atmospheric amount provide a means of gauging overall progress toward halting its growth, but individual sources must be identified better to allow optimum strategies. Improved source identification is practical. In some cases quantification of sources can be improved by regional atmospheric measurements in conjunction with global tracer transport modeling.

Carbon Dioxide. Is it realistic to keep the CO_2 growth rate from exceeding that of today? The single most important benchmark will be the annual change of CO_2 emissions. Figure 11 shows the United States record in the 1990s. The requirement to achieve the "alternative scenario" for climate forcings is that these annual changes average zero or slightly negative. It is apparent that CO_2 emissions grew at a rate that, if continued, would be inconsistent with the alternative scenario.

We suggest in the discussion above that it is realistic to aim for a lower emission rate that is consistent with the alternative scenario. This particular benchmark should receive much closer scrutiny than it has heretofore. The climate simulations and rationale presented above suggest that, if air pollution is controlled, the trend of this CO_2 benchmark, more than any other single quantity, can help make the difference between large climate change and moderate climate change.

8. Communication.

Our paper on the alternative scenario (1) was reported with a variety of interpretations in the media. As I discuss in an open letter (21), this may be unavoidable, as the media often have editorial positions and put their own spin on news stories. Overall, the media correctly conveyed the thrust of our perspective on climate change. Furthermore, I suggest in my open letter that the *Washington Post* editorial on our paper (23) represented an astute assessment of the issues.

A basic problem is that we scientists have not informed the public well about the nature of research. There is no fixed "truth" delivered by some body of "experts". Doubt and uncertainty are the essential ingredient in science. They drive investigation and hypotheses, leading to predictions. Observations are the judge.

Of course, some things are known with higher confidence than others. Yet fundamental issues as well as details are continually questioned. The possibility of finding a new interpretation of data, which provides better insight into how something in nature works, is what makes science exciting. A new interpretation must satisfy all the data that the old theory fit, as well as make predictions that can be checked.

For example, the fact that the surface of the Earth has warmed in the past century is well established, and there is a high degree of confidence that humans have been a significant contributor to this warming. However, there are substantial uncertainties about the contributions of different forcings and how these will change in the future.

In my open letter (21) I note the potential educational value of keeping an annual public scorecard of measured changes of (1) fossil fuel CO_2 emissions, (2) atmospheric CO_2 amount, (3) human-made climate forcing, and (4) global temperature. These are well-defined quantities with hypothesized relationships. It is possible to make the science understandable, and it may aid the discussions that will need to occur as years and decades pass. It may help us scientists too.

9. Summary: A Brighter Future.

The "business-as-usual" scenarios for future climate change provide a useful warning of possible global climate change, if human-made climate forcings increase more and more rapidly. I assert not only that a climatically brighter path is feasible, but that it is achievable via actions that make good sense for other reasons (22, 24). The alternative scenario that we have presented does not include a detailed strategic plan for dealing with global warming. However, it does represent the outline of a strategy, and we have argued that its elements are feasible.

It is impractical to stop CO_2 from increasing in the near term, as fossil fuels are the engine of the global economy. However, the decline of the growth rate of CO_2 emissions from 4 to 1%/year suggests that further reduction to constant emissions is feasible. The potential economic and strategic gains from reduced energy imports themselves warrant the required efforts in energy conservation and development of alternative energy sources. It is worth noting that global CO_2 emissions declined in 1998 and again in 1999, and I anticipate that the 2000 data will show a further decline. Although this trend may not be durable, it is consistent with the alternative scenario.

The other requirement in our alternative scenario is to stop the growth of non-CO_2 forcings, which means, primarily, air pollution and methane. The required actions make practical sense, but they will not happen automatically and defining the optimum approach requires research.

A strategic advantage of halting the growth of non-CO_2 forcings is that it will make it practical to stop the growth of climate forcings entirely, in the event that climate change approaches unacceptable levels. The rationale for that claim is that an ever-growing fraction of energy use is in the form of clean electrical energy distributed by electrical grids. If improved energy efficiency and non-fossil energy sources prove inadequate to slow climate change, we may choose to capture CO_2 at power plants for sequestration.

Climate change is a long-term issue. Strategies will need to be adjusted as we go along. However, it is important to start now with common-sense economically sound steps that slow emissions of greenhouse

gases, including CO_2, and air pollution. Early emphasis on air pollution has multiple immediate benefits, including the potential to unite interests of developed and developing countries. Barriers to energy efficiency need to be removed. Research and development of alternative energies should be supported, including a hard look at next generation nuclear power. Ultimately strategic decisions rest with the public and their representatives, but for that reason we need to make the science and alternative scenarios clearer.

References

1. Hansen, J., M. Sato, R. Ruedy, A. Lacis and V. Oinas, Global warming in the twenty-first century: an alternative scenario, *Proc. Natl. Acad. Sci.*, **97**, 9875-9880, 2000.
2. Intergovernmental Panel on Climate Change, *Climate Change 1995*, J.T. Houghton, L.G. Meira Filho, B.A. Callandar, N Harris, A. Kattenberg and K. Maskell (eds.), Cambridge Univ. Press, Cambridge, England, 572 pp., 1996; Intergovernmental Panel on Climate Change, *Climate Change 2000*, editors.....2001.
3. Hansen, J., R. Ruedy, A. Lacis, M. Sato, L. Nazarenko, N. Tausnev, I. Tegen and D. Koch, in *General Circulation Model Development*, ed. D. Randall, Academic Press, New York, pp. 127-164, 2000.
4. Hoffert M.I. and C.Covey, Deriving global climate sensitivity from paleoclimate reconstructions, *Nature*, **360**, 573-576, 1992.
5. Hansen, J., A. Lacis, D. Rind, G. Russell, P. Stone, I. Fung, R. Ruedy and J. Lerner, Climate sensitivity: analysis of feedback mechanisms, *Geophys. Mono.*, **29**, 130-163, 1984.
6. Hansen, J. M. Sato, L. Nazarenko, R. Ruedy, A. Lacis, D.Koch, I. Tegen, T. Hall, D. Shindell, P. Stone, T. Novakov, L. Thomason, R. Wang, Y. Wang, D. Jacob, S. Hollandsworth, L. Bishop, J. Logan, A. Thompson, R. Stolarski, J. Lean, R. Willson, S. Levitus, J. Antonov, N. Rayner, D. Parker and J. Christy, Climate forcings in the GISS SI2000 model, submitted to *J. Geophys. Res.*, 2001.
7. Levitus, S., J.I. Antonov, T.P. Boyer and C. Stephens, Warming of the world ocean, *Science*, **287**, 2225-2229, 2000.
8. Kunzil, N., R. Kaiser, S. Medina, M. Studnicka, O. Chanel, P. Filliger, M. Herry, F. Horak, V. Puybonnieux-Texier, P. Quenel, J. Schneider, R. Seethaler, J.C. Vergnaud and H. Sommer, Public health impact of outdoor and traffic-related air pollution: a European assessment, *The Lancet*, **356**, 795-801, 2000.
9. Smith, K.R., National burden of disease in India from indoor air pollution, *Proc. Natl. Acad. Sci.*, **97**, 13286-13293, 2000.
10. Streets, D.G., S. Gupta, S.T. Waldhoff, M.Q. Wang, T.C. Bond and B. Yiyun, Black carbon emissions in China, *Atmos. Envir.*, in press, 2001.
11. Jacob, D.J., J.A. Logan and P.P. Murti, Effect of rising Asian emissions on surface ozone in the United States, *Geophys. Res. Lett.*, **26**, 2175-2178, 1999.
12. Lee, S.H., H. Akimoto, H. Nakane, S. Kurnosenko and Y. Kinjo, Lower tropospheric ozone trend observed in 1989-1998 at Okinawa, Japan, *Geophys. Res. Lett.*, **25**, 1637-1640, 1998.
13. Simmonds, P.G., S. Seuring, G. Nickless and R.G. Derwent, Segregation and interpretation of ozone and carbon monoxide measurements by air mass origin at the TOR station Mace Head, Ireland from 1987 to1995, *J. Atmos. Chem.*, **28**, 45-59, 1997.
14. Brown, M.A., The role of CO_2 gases in climate policy, workshop of United States Association for Energy Economics, Washington, DC, October 16, 2000.
15. Lovins, A.B. and L. Hunter Lovins, *Climate: Making Sense and Making Money*, Rocky Mountain Institute, Snowmass, CO, http://www.rmi.org/images/other/C-/ClimateMSMM.pdf; Hawken, P.G., A.B. Lovins and L.H. Lovins, *Natural Capitalism*, Little Brown, NY, 1997, www.natcap.org.
16. Holdren, J.P., Meeting the energy challenge, *Science*, **291**, 945, 2001.
17. Wald, M.L., Industry gives nuclear power a second look, *New York Times*, April 24, 2001.
18. Ecoal, Harnessing energy with reduced emissions to atmosphere - the pace of research to generate dynamic solutions for coal, *World Coal Institute Newsletter*, **36**, December, 2000; also see Williams, R.H., presentation at symposium at Nuclear Control Institute, Washington, DC, April 9, 2001..
19. Oppenheimer, M. and R.H. Boyle, Dead Heat, Basic Books, New York, 1990.
20. Nakicenovic, N., A. Grübler and A. McDonald, *Global Energy Perspectives*, Cambridge Univ. Press, Cambridge, U.K., 1998.
21. Hansen, J., An open letter on global warming, http://naturalscience.com/ns/letters/ns_let25.html.
22. Hansen, J., A brighter future, *Clim. Change*, in press, 2001.
23. Anonymous, Hot news on global warming, *Washington Post*, page A18, August 28, 2000.
24. Hansen, J., Try a common-sense response to global warming, *International Herald Tribune*, Nov. 16, 2000.

Figures

Figure 1. Climate forcing during the Ice Age 20,000 years ago relative to the current interglacial period. This forcing of -6.6 ! 1.5 W/m^2 and the 5°C cooling of the Ice Age imply a climate sensitivity of 0.75°C per W/m^2.

Figure 2. Estimated change of climate forcings between 1950 and 2000, based on (1) with five principal aerosols delineated.

Figure 3. Climate forcings in the past 50 years, relative to 1950, due to six mechanisms (6). The first five forcings are based mainly on observations, with stratospheric H_2O including only the source due to CH_4 oxidation. GHGs include the well-mixed greenhouse gases but not O_3 and H_2O. The tropospheric aerosol forcing is uncertain in both its magnitude and time dependence.

Figure 4. Simulated and observed climate change for 1950-2000 (6). These simulations with the GISS climate model (3) employ empirical mixing rates and fixed horizontal heat transports in the ocean (5). Climate forcings are those in Figure 3.

Figure 5. Simulated temperatures and planetary energy imbalance for the forcings in Figure 3 (6). The business-as-usual scenario (1% CO_2/year) adds 2.9 W/m^2 forcing in 2001-2050. The alternative scenario adds a greenhouse gas forcing of 1.1 W/m^2 in that period and includes volcanoes similar to those during 1951-2000.

Figure 6. Cartoon depicting approximate added climate forcings in an extreme "business-as-usual" scenario and the "alternative" scenario (8).

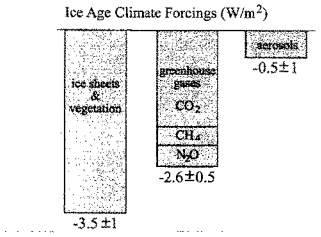
Figure 7. Measured greenhouse gas amounts and "alternative scenario" extensions to 2050. IS92a scenarios of IPCC (2) for CO_2, CH_4 and N_2O are illustrated for comparison. The sum of CFC and "other trace gas" forcings is constant after 2000 in the alternative scenario.

Figure 8. Annual emissions of CO_2 from fossil fuels in the United States (principal data source: Oak Ridge National Laboratory, Department of Energy).

Figure 9. Annual emissions of CO_2 from fossil fuels in the world (principal data source: Oak Ridge National Laboratory, Department of Energy).

Figure 10. Percentage of world fossil-fuel CO_2 emissions produced in the Untied States.

Figure 11. Annual change of United States fossil-fuel emissions.



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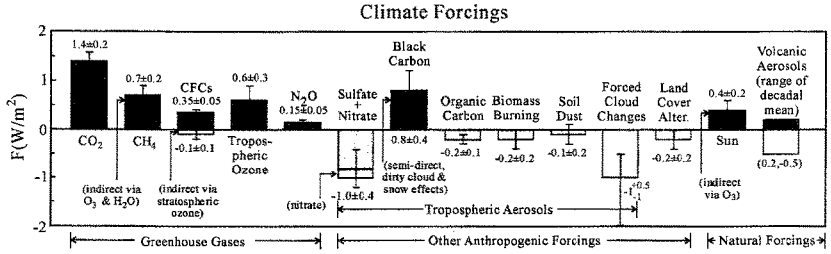
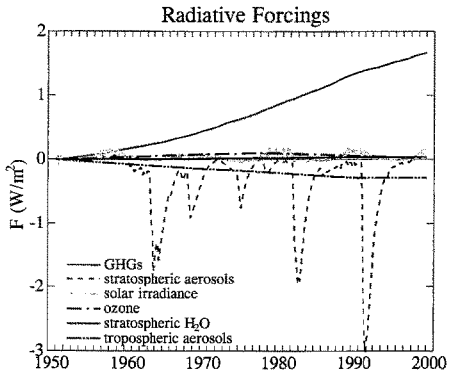
Forcing ~ 6.6 ± 1.5 W/m²
Observed ΔT ~ 5 °C
→ 3/4 °C per W/m²



Sum ~1.6 W/m²
Sensitivity 3/4°C per W/m² 1.2°C warming at equilibrium
Today: 3/4 ° C warming + 0.6 W/m² remaining imbalance

Figure 2. Estimated change of climate forcings between 1850 and 2000, based on (1) with five principal aerosols delineated.



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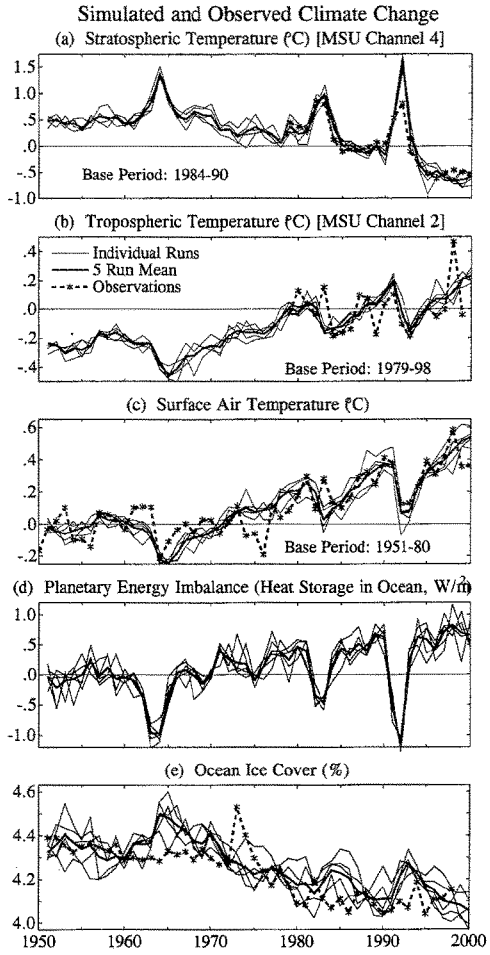

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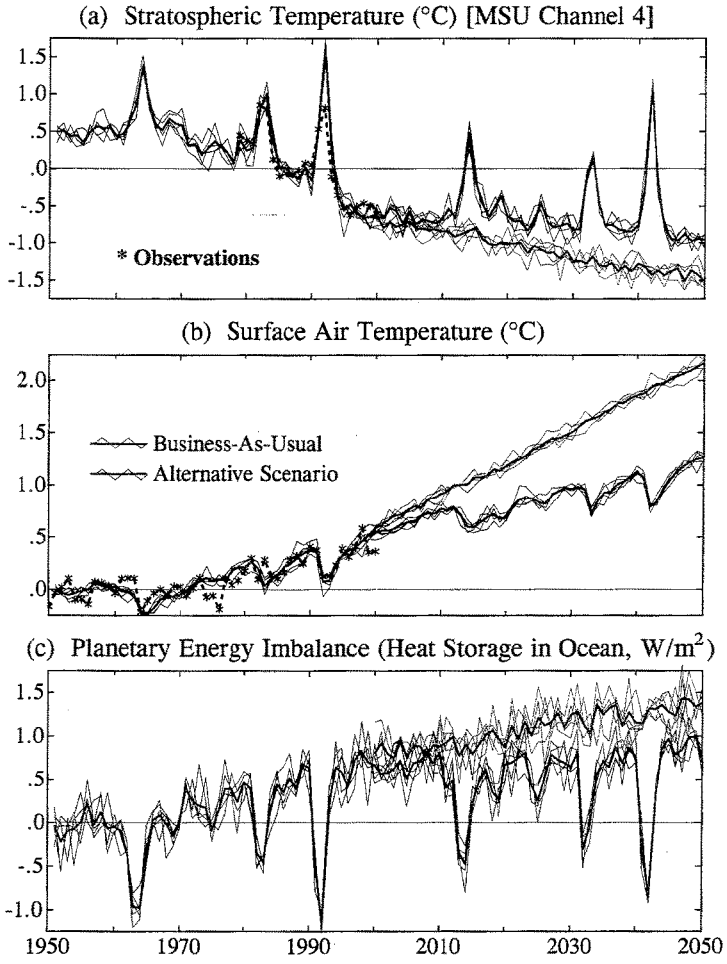

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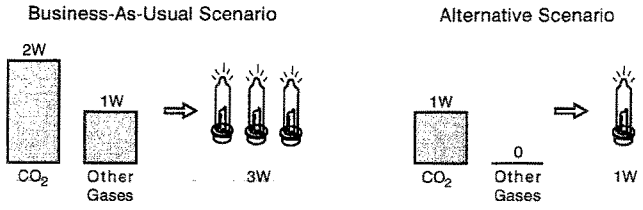

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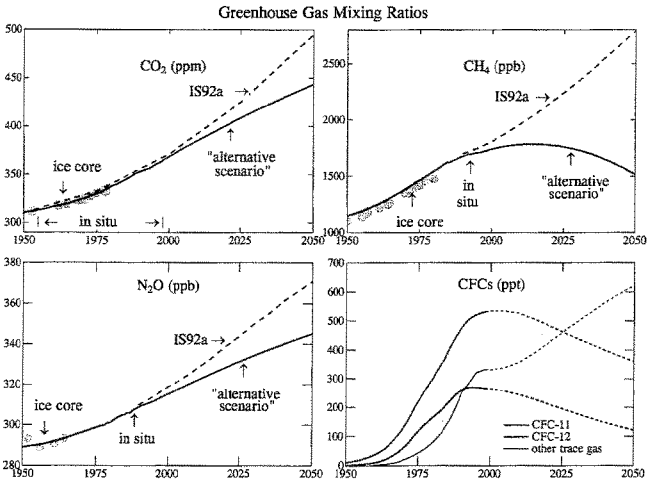

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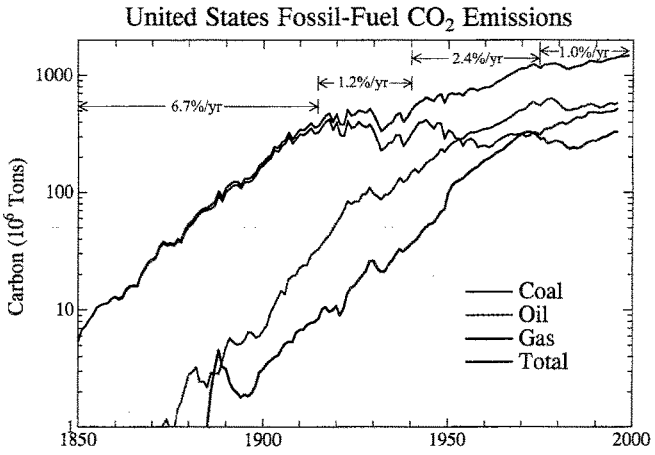

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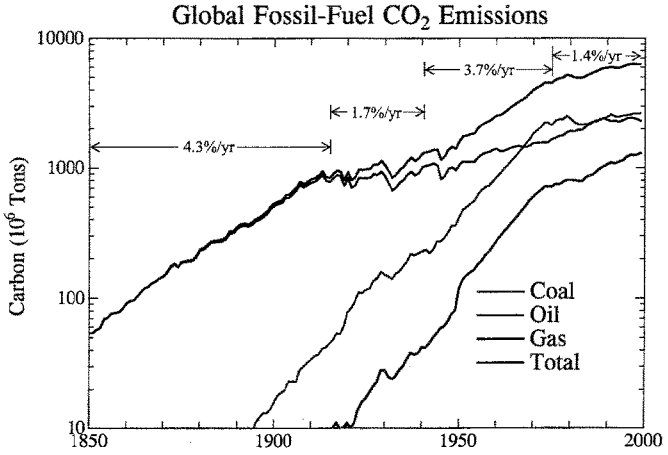

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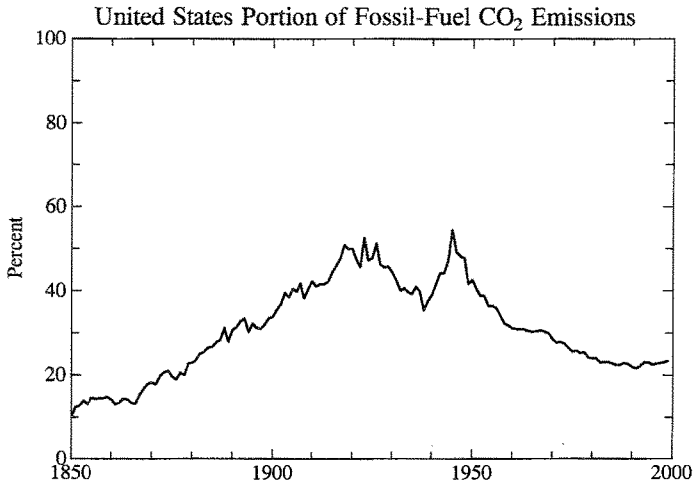

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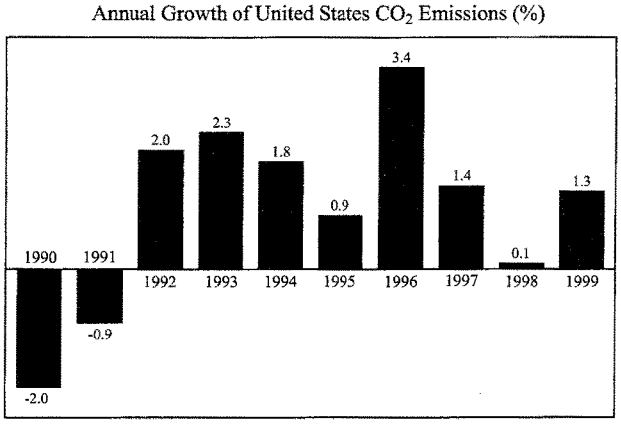


Figure 11. Annual change of United States fossil-fuel CO_2 emissions.

TESTIMONY OF

THOMAS R. KARL, DIRECTOR
NATIONAL CLIMATIC DATA CENTER
NATIONAL ENVIRONMENTAL SATELLITE DATA AND INFORMATION SERVICES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

BEFORE THE
COMMITTEE ON GOVERNMENTAL AFFAIRS
UNITED STATES SENATE

July 18, 2001

Good morning, Mr. Chairman and members of the Committee. I am Tom Karl, Director of the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC). The NCDC is the largest archive of weather and climate data in the world and it is one of three data centers operated by NOAA's National Environmental Satellite Data and Information Services line office, within the Department of Commerce. I have been invited to discuss the science of climate change.

The information I present to you today is based on the findings from two assessments, one carried out internationally and one carried out nationally. Specifically, I refer to the 2001 report of the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences (NAS) June 6, 2001, report, "Climate Change Science: Analysis of Some Key Questions." Over the past three years, I have had the privilege of working with my scientific peers as a Coordinating Lead Author and panel member, respectively, on each of these two recent assessments.

The IPCC assessment took almost three years to prepare and represents the work of hundreds of scientific authors worldwide. It is based on the scientific literature, and was carefully scrutinized by hundreds of scientific peers through an extensive peer review process. The independent NAS report was requested by the current administration, and was a consensus report compiled by an 11-member panel of leading U.S. climate scientists, including a mix of scientists who have been skeptical about some findings of the IPCC and other assessments on climate change. The NAS panel addressed a series of questions posed by the present administration.

First, I want to emphasize two fundamental issues of importance. These have been long-known, are very well understood, and have been deeply underscored in all previous reports and other such scientific summaries.

* *The natural "greenhouse" effect is real, and is an essential component of the planet's climate process.* A small percentage (roughly 2%) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The global

system responds to this trapped heat with a climate that is warmer, on the average, than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other gases are more effective at trapping heat energy from certain portions of the electromagnetic spectrum where water vapor is semi-transparent to heat escaping from the Earth's surface.

In addition to the natural greenhouse effect above, there is a change underway in the greenhouse radiation balance, namely:

* *Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat.* Direct atmospheric measurements made over the past 40-plus years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by more than 30% over the Industrial Era (since 1750), compared to the relatively constant abundance that it had over the preceding 750 years of the past millennium. The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but its increase has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions as well as how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, in the order of decades to centuries. This means they become well mixed throughout the globe.

**The increase in heat-trapping greenhouse gases due to human activities are projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice.* As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow and sea ice decrease, more of the Sun's energy is absorbed by the planet instead of being reflected back to space by the underlying snow and sea ice cover. Present evidence also suggests that as greenhouse gases increase, evaporation increases leading to more atmospheric water vapor. Additional water vapor acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60% of the warming. The magnitude of these feedback effects and others, such as changes in clouds, remain a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. Increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates.

The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

**Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate.* Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol), while others act in the same sense and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere relatively quickly (within a few days). Therefore, human generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing their reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (about 1 to 2 years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The forcing estimates in the case of the greenhouse gases are greater than for these two other forcing agents.

What do these changes in the forcing agents mean for changes in the climate system? What climate changes have been observed? How well are the causes of those changes understood? Namely, what are changes due to natural factors, and what are changes due to the greenhouse-gas increases? Is there a safe level of greenhouse gas concentrations? And, what does this potentially imply about the climate of the future? These questions bear directly on our understanding of the science of climate change.

** There is a growing set of observations that yields a collective picture of a warming world over the past century.* The global-average surface temperature has increased over the 20th Century by 0.4 to 0.8° C (0.7 to 1.4°F). This occurred both over land and the oceans. The average temperature increase in the Northern Hemisphere over the 20th Century is likely to have been the largest of any century during the past 1,000 years, based on "proxy" data (and their uncertainties) from tree rings, corals, ice cores, and historical records. The 1990s are likely to have been the warmest decade and 1998 the warmest year of the past 1000 years. Other observed changes are consistent with this warming. There has been a widespread retreat of mountain glaciers in non-polar regions. Snow cover, sea ice extent and sea ice thickness, and the duration of ice on lakes and rivers have all decreased. Ocean heat content has increased significantly since the late 1940s, the earliest time when we have adequate computer compatible records. The global-average sea level has risen between 10 to 20 centimeters (4 to 8 inches), which is consistent with a warmer ocean occupying more space because of the thermal expansion of sea water and loss of land ice.

**It is likely that the frequency of heavy and extreme precipitation events has increased as global temperatures have risen.* This is particularly evident in areas where precipitation has increased, primarily in the mid and high latitudes of the Northern Hemisphere. Other extremes have

decreased such as the frequency of extremely cold weather and the frequency of frost during the period of the instrumental record , e.g., 50 to 200 years depending on location.

* *There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.* The 1995 IPCC climate-science assessment report concluded: "The balance of evidence suggests a discernible human influence on global climate." There is now a longer and more closely scrutinized observed temperature record. Climate models have evolved and improved significantly since the previous assessment. Although many of the sources of uncertainty identified in 1995 still remain to some degree, new evidence, longer and more precise data sets, and improved understanding support the updated conclusion. Namely, recent analyses have compared the surface temperatures measured over the last 1000, 140, and 50 years to those simulated by mathematical models of the climate system, thereby evaluating the degree to which human influences can be detected. Both natural climate-change agents (solar variation and episodic, explosive volcanic eruptions) and human-related agents (greenhouse gases and aerosols) were included. The natural climate-change agents alone do not explain the warming.

* *Scenarios of future human activities indicate continued changes in atmospheric composition throughout the 21st century.* The atmospheric abundances of greenhouse gases and aerosols over the next 100 years cannot be predicted with high confidence, since the future emissions of these species will depend on many diverse factors, e.g., world population, economies, technologies, and human choices, which are not uniquely specifiable. Rather, the IPCC assessment aimed at establishing a set of scenarios of greenhouse gas and aerosol abundances, with each based on a picture of what the world plausibly could be over the 21st Century. Based on these scenarios and the estimated uncertainties in climate models, e.g., feedback effects, the resulting projection for the global average temperature increase by the year 2100 ranges from 1.3 to 5.6° C (2.3°to10.1°F). Approximately half of the uncertainty in this range is due to model uncertainties related to feedback effects and half is due to different scenarios of future emissions. Regardless of these uncertainties, such a projected rate of warming would be much larger than the observed 20th Century changes and would very likely be without precedent during at least the last 10,000 years. The corresponding projected increase in global sea level by the end of this century ranges from 9 to 88 centimeters (4 to 35 inches). Uncertainties in the understanding of some climate processes make it more difficult to project meaningfully the corresponding changes in regional climate. Future climate change will, of course, depend on the technological developments that enable reductions of greenhouse gas emissions.

There is a basic scientific aspect that has been underscored with very high confidence in all of the IPCC climate-science assessment reports (1990, 1995, and 2001). It is repeated here because it is a key (perhaps "the" key) aspect of a greenhouse-gas-induced climate change:

* *A greenhouse-gas warming could be reversed only very slowly.* This quasi-irreversibility arises because of the slow rate of removal (centuries) from the atmosphere of many of the greenhouse gases and because of the slow response of the oceans to thermal changes. For example, several centuries after carbon dioxide emissions occur, about a quarter of the increase in the atmospheric

concentrations caused by these emissions is projected to still be in the atmosphere. Additionally, global average temperature increases and rising sea levels are projected to continue for hundreds of years after a stabilization of greenhouse gas concentrations (including a stabilization at today's abundances), owing to the long time scales (decades to centuries) on which the deep ocean adjusts to climate change. Because of its large specific heat capacity and mass, the world ocean can store large amounts of heat and remove this heat from direct contact with the atmosphere for long periods of time.

**It is presently not possible to generally define a safe level of greenhouse gases.* This issue was specifically addressed in the recent NAS study. There are several difficulties related to answering this question. First, as I have indicated, there are still large uncertainties related to the projected rate and magnitude of climate change. The determination of an acceptable concentration of greenhouse gases depends on knowing this as well as knowledge of the risks and vulnerabilities to climate change. A range of climate sensitivities and emission scenarios could be used to explore sensitivities to climate change. A first attempt was reported in the National Climate Assessment and the recent IPCC report. Analyses reveal that sectors and regions vary in their sensitivity to climate change, but generally those societies and systems least able to adapt and those regions with the largest changes are at greatest risk. This includes the poorer nations and sectors of our society, natural ecosystems, and those regions likely to see the largest changes. For example, on average, the largest increases of temperature and relative changes in precipitation projected by all models are in the mid to high latitudes of the Northern Hemisphere. Clearly, as the rate and magnitude of climate change increases, the risk of exceeding a safe level of greenhouse gases also increases. This includes the possibility of surprises. As greenhouse gases continue to increase there is an ever increasing, but still very small chance, that the climate system could respond in an unpredictable fashion. Examples include a shut-down of the transport of heat in the North Atlantic Ocean thermohaline circulation which could lead to large regional climate anomalies, melting of the Greenland Ice Sheet or the Antarctic Ice Shelf, substantial increases in hurricane intensity, and other possibilities. None of these changes are foreseen at present, but we cannot absolutely dismiss the possibility of a surprisingly large and rapid change in climate.

**Because there is considerable uncertainty in current understanding of how the natural variability of the climate system reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude and impacts of future warming are subject to future adjustments (either upward or downward).* Nonetheless, it is noteworthy that our best estimates of climate sensitivity to greenhouse gases have essentially remained unchanged over the past three decades, since the first National Academy of Sciences report on this topic back in the 1960s. In addition to the uncertainty related to the rate and magnitude of climate change, there is considerable uncertainty related to quantifying the impact of climate change on natural and human systems.

**To address these uncertainties, several areas of study have been identified in the assessments.* Because understanding the climate system and its impacts is so complex, progress will be hindered by the weakest link in the chain. At the present time, there are several weak links that need to be addressed. First and foremost a climate observing system is needed to monitor long-

term change for basic variables needed to describe the climate system. Current observing systems yield uncertainties in several key parameters, especially on regional and local space scales. Although we have been able to link observed changes to human activities, it is not possible to quantitatively identify the specific contribution of each forcing factor, which is required for the most effective strategy to prevent large or rapid climate change.

To address these uncertainties, the President has directed the Cabinet-level review of U.S. climate change policy. Based on the Cabinet's initial findings, the President in his June 11 remarks committed his Administration to invest in climate science. He announced the establishment of the U.S. Climate Change Research Initiative to study areas of uncertainty and to identify areas where investments are critical. He directed the "Secretary of Commerce, working with other agencies, to set priorities for additional investments in climate change research, review such investments, and to provide coordination amongst federal agencies. We will fully fund high-priority areas for climate change science over the next five years. We'll also provide resources to build climate observation systems in developing countries and encourage other developed nations to match our American commitment."

I would like to underscore that we will use the descriptions of the uncertainties identified in the NAS report as the basis for development of U.S. research in climate. Cited areas of uncertainty include:

- Feedbacks in the climate system that determine the magnitude and rate of temperature increases and related precipitation changes
- Future usage of fossil fuels
- Carbon sequestration on land and in the ocean
- Details of regional climate change
- Natural climate variability and the interaction of these modes with other climate forcings including greenhouse gases and the direct and indirect effects of aerosols

Finally, we have found that no matter how good our understanding of future climate change might be, we ultimately must understand how this will impact natural and human systems. To achieve this understanding will require (a) interdisciplinary research that couples physical, chemical, biological, and human systems, (b) improved capability to integrate scientific knowledge, including its uncertainty, into effective decision support systems, and (c) a better understanding of the impact of multiple stresses on both human and natural systems at the regional and sectoral level.

I look forward to continuing to work with you on these issues. Thank you again for the invitation to appear today. I hope that this summary has been useful. I would be happy to address any questions.

Assessments Cited:

Committee on the Science of Climate Change. Climate Change Science: An Analysis of Some Key Questions. National Academy Press: Washington, D.C. 2001. 28 pp.

Summary for Policy Makers, Climate Change 2001: The Scientific Basis. Summary for Policymakers and Technical Summary of the Working Group I Report. Cambridge University Press, 98pp. Also available at http://www.ipcc.ch. The full report will be available later this summer.

Parallel IPCC reports:

Climate Change 2001: Impacts, Adaptation and Vulnerability - Contribution of Working Group II to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report.

Climate Change 2001: Mitigation - Contribution of Working Group III to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report.

IPCC, 2000: IPCC Special Report on Emissions Scenarios. Cambridge University Press.

Statement by
Eileen Claussen
Pew Center on Global Climate Change
Before the Governmental Affairs Committee
United States Senate
July 18, 2001

Mr. Chairman and members of the committee, thank you for this opportunity to testify on S.1008, the Byrd-Stevens Climate Change Strategy and Technology Innovation Act of 2001. My name is Eileen Claussen, and I am the President of the Pew Center on Global Climate Change.

The Pew Center on Global Climate Change is a non-profit, non-partisan and independent organization dedicated to providing credible information, straight answers and innovative solutions in the effort to address global climate change. Thirty-six major companies in the Pew Center's Business Environmental Leadership Council (BELC), most included in the Fortune 500, work with the Center to educate the public on the risks, challenges and solutions to climate change. (See Attachment A for the list of companies.) The BELC companies do not contribute financially to the Center.

Mr. Chairman, I believe that enacting the Byrd-Stevens bill will be an important first step in developing a serious domestic climate change program -- a step that should be taken quickly. This bipartisan bill will align our energy policy with the long-term goal of stabilizing atmospheric greenhouse gas concentrations. It will respond to concerns, often raised by other nations, that the U.S. has no basis for domestic action. And it will continue investigation into the uncertainties of the science and economics of climate change.

Most important among the many provisions of the Byrd-Stevens bill is the one that requires the development, within one year, of a U.S. Climate Change Response Strategy. This strategy will have the long-term goal of stabilizing greenhouse gas concentrations. To meet this goal, the strategy will rely on emissions mitigation measures, technology innovation, climate adaptation research, and efforts to resolve the remaining scientific and economic uncertainty. Allow me to comment on these elements.

At the Pew Center, we believe enough is known about the science and environmental impacts of climate change for us to take action now. As we have learned from the Intergovernmental Panel on Climate Change (IPCC), confirmed recently by the National Academy of Sciences (NAS), the scientific consensus is very strong that greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Human-induced warming and associated sea level rises are expected to continue through the 21st century. We are also likely to see increases in rainfall rates in some areas and increased

susceptibility of semi-arid regions to drought. As a consequence, according to the IPCC and NAS reports and our own peer-reviewed reports there likely will be substantial impacts to human health, agriculture, ecosystems, and coastlines. The high probability of these outcomes indicates the need for action now.

Even as we act, however, we need to refine our understanding of the causes and impacts of climate change – especially as they affect particular regions of our country and the world. This is will be especially important in developing the measures needed to adapt to climate change. Regardless of how quickly we act to mitigate climate change, the best scientific evidence tells us that we have already "bought" a changed climate to which we and our children will need to adapt. Obviously, the more quickly we mitigate, the less we will have to adapt, but some amount of adaptation is apparently inevitable.

For example, on the whole, U.S. agriculture is likely to adapt to the increases in temperature, droughts, floods, and evaporation rates expected over the next century. In specific regions of the U.S., however, the impacts might be significant. The sooner we can identify those regions, the sooner we can prepare the people and economies of those regions to adapt. The Byrd-Stevens bill creates a sound basis for giving priority to and investigating these issues.

We also applaud efforts to further analyze the uncertainties regarding the economic impacts of climate change. Work done by the Pew Center suggests that no existing model accurately predicts the economic effects of any given measure to mitigate climate change. Therefore, none of the cost information so handily bandied about can currently be viewed as reliable. We are hard at work to fill in many of the gaps in the models, but efforts, particularly to take the economic assessment to regional levels, would be most welcome.

Second, the Byrd-Stevens bill will promote technology innovation. In May, Senator Byrd said from the Senate floor that to address global climate change, "[w]hat is required ... is the equivalent of an industrial revolution." He was exactly right. To effectively address climate change, we need to lower carbon intensity, become more energy efficient, promote carbon sequestration, and find ways to limit emissions of non-CO_2 gases. This will require fundamentally new technologies, as well as dramatic improvements in existing ones. New, less carbon-intensive ways of producing, distributing and using energy will be essential. The redesign of industrial processes, consumer products and agricultural technologies and practices will also be critical. These changes can be introduced over decades as we turn over our existing capital stocks and establish new infrastructure. But we must begin making investments, building institutions, and implementing policies now. The Byrd-Stevens bill will provide a solid foundation for needed revolution in technology.

I applaud the Senators' efforts to deal with the very real institutional and budgetary challenges that have plagued federal energy research and development and technology diffusion for many years. I endorse the proposal in S. 1008 to create a new research and technology organization with a clear mission to foster the best, most cost-

effective ways to reduce greenhouse gases, along with a significant increase in funding. In addition, the Senate may want to consider establishing stable funding for research and development. The Senate may also want to consider increasing the emphasis on public-private partnerships, which have yielded some of the greatest federal R&D successes in years past.

Third, under the Byrd-Stevens bill, the Climate Change Response Strategy will be required to incorporate mitigation approaches to reduce, avoid, and sequester greenhouse gas emissions. This is an extremely important provision, and will force us to take a hard look at our policy choices.

We believe that it will be extraordinary difficult, if not impossible, to muster the kind of sustained effort needed to reduce, avoid and sequester greenhouse gas emissions without the force of legally binding commitments. There is little incentive for any company to undertake real action unless, ultimately, all do, and are in some manner held accountable. Markets, of course, will be instrumental in mobilizing the necessary resources and know-how; market-based strategies such as emissions trading will also help deliver emissions reductions at the lowest possible cost. But markets can move us in the right direction only if they are given the right signals. In the United States, those signals have been neither fully given nor fully accepted.

Three decades of experience fighting pollution in the United States have taught us a great deal about what works best. In general, the most cost-effective approaches allow emitters flexibility to decide how best to meet a given, binding emissions limit; provide early direction so targets can be anticipated and factored into major capital and investment decisions; and employ market mechanisms, such as emissions trading, to achieve reductions where they cost least. To ease the transition from established ways of doing business, targets should be realistic and achievable. What is important is that they be strong enough to spur real action and to encourage investment in development of the technology and infrastructure needed to achieve the long-term objective.

A good first step is to get our house in order by immediately requiring accurate measurement, tracking and reporting of greenhouse gas emissions. In addition, the government could enter into voluntary enforceable agreements with companies or sectors willing to commit to significant reductions.

While such efforts can help get the United States on track, the long-term emission reductions needed can be achieved only with a far more comprehensive—and binding—strategy. Alternative approaches should be closely studied, and the results publicly debated. But much of the analysis thus far suggests that a "cap-and-trade" system—which sets an overall cap on emissions and establishes a market in carbon credits—can provide the private sector the certainty they need coupled with the flexibility and incentive to achieve emission reductions at the least possible cost.

An effective Climate Change Response Strategy will incorporate these and other mitigation measures.

As a side note, I should point out that congressional debate over the mitigation measures should start now, and not await completion of the strategy – especially since the debate will take some time to resolve. As Senator Byrd said when he introduced his bill, "[t]his legislation is intended to supplement, rather than replace, other complementary proposals to deal with climate change in the near term on both a national and international level."

In closing, Mr. Chairman, the Byrd-Stevens Climate Change Strategy and Technology Innovation Act of 2001, if enacted quickly and implemented in a serious manner, will provide an excellent foundation for climate change policy in this country. Thank you for the opportunity to testify in support of it.

ATTACHMENT A

Business Environmental Leadership Council

ABB
Air Products and Chemicals
Alcoa
American Electric Power
Baxter International
Boeing
BP
California Portland Cement Co.
CH2M HILL
Cinergy Corp.
Cummins Inc.
Deutsche Telekom
DTE Energy
DuPont
Enron
Entergy
Georgia-Pacific
Holnam
IBM
Intel
Interface Inc.
John Hancock Financial Services
Lockheed Martin
Maytag
Ontario Power Generation
PG&E Corporation
Rio Tinto
Rohm and Haas
Royal Dutch/Shell
Sunoco
Toyota
TransAlta Corp.
United Technologies
Weyerhaeuser
Whirlpool
Wisconsin Energy Corporation

The Role of Energy Technology in Stabilizing Greenhouse Gas Concentrations

Statement to the
Senate Committee on
Governmental Affairs

James Edmonds
Senior Staff Scientist
Pacific Northwest National Laboratory
Battelle Memorial Institute

July 18, 2001

Thank you Mr. Chairman and members of the Committee for the opportunity to testify here this morning on the potential contribution of energy technology to addressing the issue of global climate change. My presence here today is possible because the US Department of Energy, EPRI and numerous other organizations in both the public and private sectors have provided me and my team at the Pacific Northwest National Laboratory (PNNL) long-term research support. Without that support much of the knowledge base upon which I draw today would not exist. That having been said, I come here today to speak as a researcher and the views I express are mine alone. They do not necessarily reflect those of any organization.

My observations today draw upon the work that was conducted under the Global Energy Technology Strategy Program to Address Climate Change, an international, public/private sector collaboration[1] advised by an eminent Steering Group[2]. Analysis

[1] Sponsors of the program were: Battelle Memorial Institute, BP, EPRI, ExxonMobil, Kansai Electric Power, National Institute for Environmental Studies (Japan), New Economic and Development Organization (Japan), North American Free Trade Agreement–Commission for Environmental Cooperation, PEMEX (Mexico), Tokyo Electric Power, Toyota Motor Company, and the US Department of Energy. Collaborating research institutions were: The Autonomous National University of Mexico, Centre International de Recherche sur l'Environnment et le Developpement (France), China Energy Research Institute, Council on Agricultural Science and Technology, Council on Energy and Environment (Korea), Council on Foreign Relations, Indian Institute of Management, International Institute for Applied Systems Analysis (Austria), Japan Science and Technology Corporation, National Renewable Energy Laboratory, Potsdam Institute for Climate Impact Research (Germany), Stanford China Project, Stanford Energy Modeling Forum, and Tata Energy Research Institute (India).

[2] Richard Balzhiser, President Emeritus, EPRI; Richard Benedick, Former US Ambassador to the Montreal Protocol; Ralph Cavanagh, Co-director, Energy Program, Natural Resources Defense Council; Charles Curtis, Executive Vice President, United Nations Foundation; Zhou Dadi, Director, China Energy Research Institute; E. Linn Draper, Chairman, President and CEO, American Electric Power; Daniel Dudek, Senior Economist, Environmental Defense Fund; John H. Gibbons, Former Director, Office of Science and Technology Policy, Executive Office of the President; José Goldemberg, Former Environment Minister, Brazil; Jim Katzer, Strategic Planning and Programs Manager, ExxonMobil; Yoichi Kaya, Director, Research Institute of Innovative Technology for the Earth, Government of Japan; Hoesung Lee, President, Korean Council on Energy and Environment; Robert McNamara, Former President, World Bank; John

conducted at the Pacific Northwest National Laboratory as well as in collaborating institutions around the world during the first phase of research supports four general conclusions:

1. **It's concentrations of greenhouse gases that matter.** For CO_2, it is cumulative, emissions by all countries, over all time that determines the concentration—not emission by any individual country, no matter how great, or any individual year;
2. **Technology is the key to controlling the cost of stabilizing the concentration of greenhouse gases;**
3. **There's No "Silver Bullet."** That is, no single technology controls the cost of stabilizing CO_2 concentrations under all circumstances. Managing the cost of stabilizing the concentration of greenhouse gases, at any level, requires a portfolio of energy R&D investments across a wide spectrum of technology classes—from conservation to renewables to nuclear to fossil fuels, to hydrogen systems and fuel cells to biotechnology, to natural and engineered carbon capture and sequestration and advanced fossil fuel energy systems, and undertaken by both the public and private sectors.
4. **Energy Technology Development Is One Part of a Larger Comprehensive Strategy.** While technology is pivotal when it comes to controlling the cost of stabilizing the concentration of greenhouse gases, it is only one of four major elements that are needed in a comprehensive program to address climate change including:
    1. Reduction of scientific uncertainties,
    2. Adaptation to climate change, and
    3. A credible, global commitment that greenhouse gas concentrations will be limited, as well as
    4. Energy technology R&D.

1. It's Concentrations of Greenhouse Gases That Matter. The United States is a party to the Framework Convention on Climate Change (FCCC). The FCCC has as its objective the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (Article 2) This is not the same as stabilizing emissions. Because emissions accumulate in the atmosphere, the concentration of carbon dioxide will continue to rise indefinitely even if emissions are held at current levels or even at some reduced level. Limiting the concentration of CO_2, the most important greenhouse gas, means that the global energy system must be fundamentally transformed by the end of the 21st century. Given the long life of energy infrastructure, preparations for that transformation must start today.

Mogford, Group Vice President, Health, Safety and Environment BP; Granger Morgan, Professor, Carnegie-Mellon University; Hazel O'Leary, Former Secretary, US Department of Energy; Rajendra K. Pachauri, Director, Tata Energy Research Institute; Thomas Schelling, Distinguished University Professor of Economics, University of Maryland; Hans-Joachim Schellnhuber, Director, Potsdam Institute for Climate Impact Research; Pryadarshi R. Shukla, Professor, Indian Institute of Management; Gerald Stokes, Assistant Laboratory Director, Pacific Northwest National Laboratory; John Weyant, Director, Stanford Energy Modeling Forum; and Robert White, Former Director, National Academy of Engineering.

A popular myth is that the world is running out of fossil fuels and will therefore make a natural transition to an energy system based on renewables and conservation during this century, thus leading to a natural limit on cumulative carbon emissions. The reality is that while the most attractive grades of fossil fuel resources may be limited, fossil fuels as a class are abundant and hold the potential of remaining the core of the global energy system throughout the century ahead.

Growth in population and incomes can be expected to require a concurrent growth in the demand for energy services. It is this growth in demand for energy services coupled with the abundance and usefulness of fossil fuels that is anticipated to lead a continued growth in cumulative global emissions of carbon to the atmosphere throughout the 21st century. Given these two facts, research designed to enable the continued use of fossil fuels while simultaneously addressing the climate issue is particularly attractive.

Limiting cumulative global emissions implies that the global energy system, not just the United States energy system, must undergo a transition from one in which emissions continue to grow throughout this century into one in which emissions peak and then decline. Coupled with significant global population and economic growth, this transition represents a daunting task even if an atmospheric CO_2 concentration as high as 750 ppmv is eventually determined to meet the goal of the Framework Convention—though the concentration that will prevent "dangerous" interference with the climate system is not yet known.

2. Technology is the key to controlling the cost of stabilizing the concentration of greenhouse gases. Stabilizing the concentration of greenhouse gases in the atmosphere will require a credible commitment to limit cumulative global emissions of CO_2. Such a limit is unlikely to be achieved without cost but that cost will in large measure be shaped by the character of the energy technology options available to limit cumulative global emissions of CO_2.

It is not well recognized that most long-term future projections of global energy and greenhouse gas emissions and hence, most estimates of the cost of emission reductions, assume dramatic successes in the development and deployment of advanced energy technologies that occur for free. For example, the Intergovernmental Panel on Climate Change developed a set of scenarios based on the assumption that no actions were implemented to mitigate greenhouse gas emissions. The central reference case that assumes "technological change as usual" is called IS92a. This central reference scenario assumes that by the year 2100 three-quarters of all electric power would be generated by non-carbon emitting energy technologies such as nuclear, solar, wind, and hydro, and that the growth of crops for energy (commercial biomass) would account for more energy than the entire world's oil and gas production in 1985. Yet with all these assumptions of technological success, the need to provide for the growth in population and living standards around the world drive fossil fuel emissions well beyond 1997 levels of 6.6 billion metric tons of carbon per year to approximately 20 billion metric tons of carbon per year. Subsequent analysis by the IPCC as well as independent researchers serves to

buttress the conclusion that even with optimistic assumptions about the development of conventional energy technologies that the concentration of CO_2 in the atmosphere can be expected to continue rise throughout the century. Thus, achieving stabilization of greenhouse gas concentrations will require an investment in basic research and new technology development well above these assumptions.

Technology development is critical to controlling the cost of stabilizing CO_2 concentrations. Improved technology can both reduce the amount of energy needed to produce a unit of economic output and lower the carbon emissions per unit of energy used. Analysis conducted under the Global Energy Technology Strategy Program showed that the availability of cost effective renewable, nuclear, hydrogen systems and fuel cells, and a variety of mechanisms to capture and sequester carbon in addition to improved conservation and fossil fuel technologies, could dramatically reduce the cost of limiting cumulative global net carbon emissions.

3. There's No "Silver Bullet." No single technology controls the cost of stabilizing CO_2 concentrations under all circumstances. The portfolio of energy technologies that is employed varies across the world's regions and over time. Regional differences in such factors as resource endowments, institutions, demographics and economics, inevitably lead to different technology mixes in different nations, while changes in technology options inevitably lead to different technology mixes across time.

Technologies that are potentially important in stabilizing the concentration of CO_2 include energy efficiency and renewable energy forms, non-carbon energy sources such as nuclear power and fusion, improved applications of fossil fuels, and technologies such as terrestrial carbon capture by plants and soils, carbon capture and geologic sequestration, fuel cells and advanced energy storage systems, and commercial biomass and biotechnology. The latter holds the promise of revolutionary change for a wide range of energy technologies. Many of these technologies are undeveloped or play only a minor role in their present state of development. Research and development by both the public and private sectors will be needed to provide the scientific foundations needed to achieve improved economic and technical performance, establish reliable mechanisms for monitoring and verifying the disposition of carbon, and to develop and market competitive carbon management technologies. For example, advances in the biological sciences and biotechnology hold the promise of dramatically improving the competitiveness of commercial biomass as an energy form and potentially opening up new pathways for revolutionary breakthroughs in other technologies such as carbon capture and sequestration.

4. Energy Technology Development Is One Part of a Larger Comprehensive Strategy. While technology is pivotal when it comes to controlling the cost of stabilizing the concentration of greenhouse gases, it is only one of four major elements that are needed in a comprehensive program to address climate change. The four elements are:

1. Reduction of scientific uncertainties,

2. Adaptation to climate change,
3. A credible, global commitment that greenhouse gas concentrations will be limited; and
4. Energy technology R&D.

In summary, stabilizing the concentration of greenhouse gases at levels ranging up to 750 ppmv represents a daunting challenge to the world community. Energy related emissions of CO_2 must peak and begin a permanent decline during this century. Both a credible global commitment to limit cumulative emissions and a portfolio of technologies will be needed to minimize the cost of achieving that end, including technologies that are not presently a significant part of the global energy system. While important, energy technology development alone will not be enough. It must be complemented by a commitment to resolve scientific uncertainties, facilitate adaptation to climate change that cannot be avoided, and a credible, global commitment that greenhouse gas concentrations will be limited.

Mr. Chairman, thank you for this opportunity to testify. I will be happy to answer your and the committee's questions.

Testimony of
Dale E. Heydlauff
Senior Vice President-Environmental Affairs
American Electric Power Company

Mr. Chairman, Senator Thompson, Senator Stevens, and Members of the Committee, my name is Dale Heydlauff. I am the Senior Vice President for Environmental Affairs at American Electric Power Company. I am delighted to join on this panel Dr. Jae Edmonds of Battelle, as Dr. E. Linn Draper, AEP's Chairman and CEO, served on the steering group of Battelle's Global Energy Technology Strategy Program and Eileen Claussen, the President of the Pew Center on Global Climate Change, as AEP is one of the founding companies of the Center's Business Environmental Leadership Council.

AEP is a multinational energy company based in Columbus, Ohio. AEP owns and operates more than 38,000 megawatts of generating capacity, making it America's largest generator of electricity. AEP generates about 6% of the electricity in the United States, a figure comparable to the annual electric power consumption in Mexico and Australia. We are the largest consumer of coal and the third largest consumer of natural gas in the U.S. AEP provides retail electricity to more than 6.8 million customers worldwide and has more than $55 billion in assets, primarily in the U.S. with holdings in select international markets.

Given AEP's reliance on coal and natural gas to produce reliable and affordable electricity for our customers, we are one of the largest emitters of carbon dioxide emissions in the country, and we are committed to dealing with the challenge posed by climate change. At AEP, we accept the views of most scientists that enough is known about the science and environmental impacts of global climate change for us to take action to address its consequences. This recognition led us to be a proactive participant in organizations and activities that seek solutions to the challenge posed by climate change.

We have participated in several industry-government programs over the past several years that are designed to mitigate greenhouse gas emissions. We worked extensively with the U.S. Department of Energy in the creation of the Climate Challenge Program, a voluntary partnership with the electric utility industry to reduce, avoid or sequester greenhouse gas (GHG) emissions. We have identified a broad array of activities across AEP operations to limit GHG emissions – ranging from improved efficiencies in our coal and hydroelectric plants, to customer-based conservation efforts, to planting 15 million trees on 20,000 acres of company-owned land.

In addition to our interest in technological solutions to the challenge of climate change, I would like to briefly note that AEP has also been active in terrestrial carbon sequestration projects. Our efforts in this regard are part of our larger commitment to environmental stewardship, and our strategy to find effective ways to protect and enhance the environment while providing reliable electricity at a competitive cost. These projects

also reflect our belief that there are many solutions that can result in multiple environmental benefits. We are partners in the largest tropical forest preservation and carbon sequestration project in the world, the Noel Kempff Mercado Climate Action Project in Bolivia. This effort allowed Bolivia to double the size of the Noel Kempff Mercado National Park. It now spans 3.7 million acres – only Denali National Park in Alaska is larger. The Noel Kempff Mercado project protects one of the most biologically diverse areas in the world. AEP is also involved in the Guaraqueçaba Climate Action Project which will restore and protect approximately 20,000 acres of partially degraded and/or deforested sub-tropical forest within the Guaraqueçaba Environmental Protection Area in southern Brazil. It promotes natural forest regeneration and regrowth on pastures and degraded forests within the project area. It will also protect standing forest that still exists but is under threat of deforestation. Most recently, we announced our participation in the Catahoula National Wildlife Refuge Reforestation Project in Louisiana, which results from an innovative partnership that includes the U.S. Fish and Wildlife Service. This project tripled the size of the existing wildlife refuge, and we are reforesting about 10,000 acres with bottomland hardwoods.

We recognize, however, that forestry projects alone will not be enough to deal with the magnitude of the challenge that we face. The primary anthropogenic contributor to climate change is CO2 emissions that result from the burning of fossil fuels. AEP has long recognized that we face an enormous challenge if we are to develop and deploy cost-effective technologies to reduce greenhouse gas emissions. Our concern led AEP to actively support the Battelle project and similar efforts by EPRI. These projects not only deal with the infrastructure represented by our fleet of coal-fired power plants, but also address the world's energy system that today is powered by oil, coal, and natural gas. There is every reason to believe that the world will continue to rely on these fossil fuels as its primary energy sources for quite some time.

In his recent floor statement, Senator Byrd expressed it well when he said that "what is required, then, is the equivalent of an industrial revolution. We must develop new and cleaner technologies to burn fossil fuels as well as new methods to capture and sequester greenhouse gases, and we must develop renewable energy technology that is practical and cost-effective. Rarely has mankind been confronted with such a challenge -- a challenge to improve how we power our economy."

AEP believes that the legislation introduced by Senators Byrd and Stevens represents one of the single most important legislative initiatives yet introduced in Congress to deal with climate change. Mr. Chairman, along with my testimony, I would like to submit for the record a letter to Senator Byrd from Dr. E. Linn Draper, Jr., Chairman of the Board, President, and Chief Executive Officer of AEP, dated May 21, that endorses the bill and notes that the legislation "is inherently an expression of optimism and faith in our future. You forthrightly state that the problem is real and growing. Your bill provides the vision, the commitment, and the framework for the solution to this global commons problem."

S. 1008 recognizes that our nation's commitment to solving this problem is, in fact, directly related to whether we undertake the necessary research to develop the technological solutions that we will need. But what the public may not be aware of is that even while press coverage and public awareness of climate change is increasing, our national expenditures in the area of research and development have sharply declined.

A recent update of research carried out under the Battelle Global Energy Technology Strategy Project demonstrated that US public and private sector investments in energy research and development (R&D) are currently at a 26 year low of approximately $3.7 billion. Energy R&D expenditures have been in decline since approximately 1980 and investments in energy R&D fell in real terms by 47% during the last decade. The U.S. energy industry today invests about 0.5% of its revenues in research and development, and the trend continues to move downward. In comparison, the computer, pharmaceutical, and telecommunication industries invest about 10%, and the overall U.S. industry average is around 7%. Energy has been, and remains, at the bottom of the R&D investment ladder, a prescription leading to a precarious future, especially given the increasingly central role that energy will play in global economic and environmental issues in this century. Earlier analyses carried out by Battelle confirmed that this same disturbing trend of significant disinvestments in energy R&D can be found in many of the other large developed nations that sponsored energy R&D during the past decade.

As investments in research and development have declined, the emphasis within many companies has shifted to those technologies that can be brought to market in the near term, to provide tangible solutions to today's pressing problems. In many cases, companies are motivated by the immediate environmental compliance challenges facing them. To the degree that climate change is addressed, it is usually evolutionary improvements in existing technologies, like efficiency increases, not the revolutionary new technologies that will be required in a carbon constrained world.

Any technology strategy must also recognize the long lead-time to develop new technologies to the point of commercial viability. New technology becomes cost competitive only when multiple units are constructed and cost savings are identified from engineering improvements. The Byrd-Stevens bill includes provisions to foster this commercial scale development and deployment.

Industry alone does not have the financial resources to meet the technology development and deployment challenge, and neither does the public sector. This must be a partnership -- indeed one of the most critical joint efforts that the public and private sectors must undertake during the next century.

In the case of the utility industry, deregulation and privatization around the world are introducing competition into the electric power sector, resulting in downward pressure on the future price curve for electricity. The construction of new generation will slow and use of existing assets will be extended. This reflects the fact that power plants

have a useful economic life of 60-70 years. The highest cost and unsustainable approach to greenhouse gas mitigation is to impose stringent and immediate reductions in greenhouse gases if that caused the premature retirement of some of these assets and their replacement with only marginally lower emitting technologies. This would siphon capital away from new technology development. One simply cannot afford to spend limited capital to achieve emission reductions from existing technology and simultaneously develop the bold, breakthrough technologies needed to stabilize atmospheric concentrations of greenhouse gases.

However, such flexibility with regard to when capital stock is replaced carries with it an obligation to develop a new generation of highly efficient and less carbon intensive technologies so that they are available to replace the current capacity when it reaches the end of its economic life. This is not an argument for complacency or an excuse to avoid spending public and private resources in a search for solutions. To the contrary, this is a call to action – a belief that it is imperative that we begin now to take maximum advantage of this window of opportunity to accelerate the development of cleaner and less carbon-intensive technologies.

The findings in the legislation observe that what is needed is a "transformational change in the global energy system," and that this can happen only if it "is preceded by research and development that leads to bold technological breakthroughs." The bill addresses this concern by creating a new office within the Department of Energy charged with the development of bold, breakthrough technologies that "moves technology substantially beyond the state of usual innovation."

The Byrd-Stevens legislation implicitly recognizes that some of the most important bold, innovative research will be undertaken initially by academic, research, and governmental institutions. When this technology moves closer to commercial reality, collaborative relationships that include cost sharing can be developed. We should also recognize that there are no guarantees. Some of these technological efforts will succeed. Some will fail. But we must start now.

What will the consequences be to our nation if we fail to undertake this effort or if we do not allow enough time to develop and deploy the necessary technology? Or if we do not have a long-term approach? At a minimum, the cost to our nation would significantly increase. In the absence of technological breakthroughs, we will not have developed the cost-effective technological solutions that will be required to address climate change.

The legislation introduced by Senators Byrd and Stevens recognizes the necessity of defining our long-term objectives in order to accomplish these goals. S. 1008 states that this effort begins with the creation of a national strategy that has the long-term goal of the stabilization of greenhouse gas concentrations, as called for in the United Nations Framework Convention on Climate Change (UNFCC), otherwise known as the Rio Treaty. The United States ratified the UNFCC in 1992, and its ultimate objective is "the

stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The bill then defines a technological path toward attainment of the long-term stabilization goal. It calls for the examination of a range of emission reduction targets and implementation dates (not just a single date or target) that would be necessary to culminate in a stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, and that can be achieved in an environmentally and economically sound manner.

Implicitly, the bill is asking what would the world have to do at each interim step along the way? What types of technologies would have to be developed to reach this range of targets and dates? What targets and dates are practical and possible, given the anticipated development of technology? What is the best path to develop and deploy these technologies, and to avoid extraordinarily costly premature retirement of factories, power plants, and other capital stock? The bill does not explicitly address these issues, but they, as well as other economic and environmental questions, would all be logical components of a national research and development strategy. It is also important to note that the strategy does not impose targets or dates on the economy, but uses these for planning purposes as part of our research and development effort, and to guide the national debate on these issues. Without this type of rational planning process, one that properly directs our national effort at the long-term goal of stabilizing greenhouse gas concentrations, we simply will not succeed in meeting the enormous challenge ahead of us. The Byrd-Stevens legislation, by focusing on the design, management, and oversight of a technology strategy, can place us on a path toward realizing that objective.

S. 1008 represents the first comprehensive attempt to respond to these issues. It provides the administrative structure within the White House, and DOE, as well as the long-term strategy, to begin a serious national effort to develop the breakthrough technologies that we will require. Without this visionary perspective, there is a risk that the nation, and the world, will waste precious resources. It is not enough to simply increase appropriations.

The Byrd-Stevens bill clearly recognizes that an administrative structure without a strategy is nothing more than a suite of offices in search of a mission. A strategy without a bureaucratic structure is little more than an announcement of well-intentioned goals upon which we can all agree, without providing the functional means to execute the mission. Senators Byrd and Stevens have wisely provided both and ensured that the strategy would remain on track through the creation of an independent review board that annually would report to Congress.

S. 1008 also recognizes the global nature of the climate change problem, as the bill acknowledges the importance of including international aspects, such as technology transfer and the global diffusion of our research and development efforts. On one hand, the U.S. cannot shoulder the burden alone. We must collaborate with other industrialized nations and with our allies. On another level, the greenhouse gas emissions of the

developing nations will eclipse the developed countries by around 2010. We live in a global commons, and CO2 that is emitted anywhere on earth affects the entire planet. Invention of the most efficient technologies in the world, even coupled with the most effective carbon capture and use/disposal imaginable, will prove useless in the face of global climate change unless we can get them deployed quickly and on a massive scale to the developing world. As part of this technology strategy, the U.S. has an obligation to assist the developing world in meeting their aspirations for sustainable development.

This will be of even greater importance in nations such as China and India, which heavily depend on coal, and which are expected to account for over 90% of the total increase in global coal consumption. According to the International Energy Agency, China's coal consumption in 1996 was 700 million tons. Their projected coal consumption in 2015 is 2.1 billion tons. China's CO2 emissions are projected to equal those of the U.S. around 2015. When it comes to climate change, particularly in some of the largest emitting nations in the developing world, clean coal technology is where "the rubber meets the road" -- they have every intention of using indigenous coal, and our responsibility is to help them do this in a sustainable manner.

American Electric Power hopes that the S. 1008 is expeditiously enacted into law, and that the Congress and the Administration will then provide the human and financial resources to turn this vision into a reality.

Thank you for the opportunity to testify today on this important issue.

American Electric Power
1 Riverside Plaza
Columbus, OH 43215-2373

The Honorable Robert C. Byrd
United States Senate
311 Hart Senate Office Building
Washington, D.C. 20510

May 21, 2001

Dear Senator Byrd:

E. Linn Draper, Jr.
Chairman of the Board
President and
Chief Executive Officer

I am writing to commend you for your record of leadership on the issue of climate change, and specifically to endorse your bill, the *Climate Change Strategy and Technology Innovation Act of 2001*. Your sponsorship of this legislation demonstrates that you are again addressing the key issues in the evolving debate over global climate change in a prudent and proactive manner.

What is most commendable about the *Climate Change Strategy and Technology Innovation Act* is that it recognizes that the world has little hope of ever stabilizing atmospheric concentrations of greenhouse gases without the development and global deployment of a new generation of highly efficient and low-carbon technologies. By beginning the necessary research and development efforts now, we can have these revolutionary new technologies available to replace the existing energy infrastructure of the developed world when it is retired, and achieve the goal of atmospheric stabilization without harming the economy of the U.S. and other developed nations. These technologies can also be exported to developing countries so they can leapfrog the technology development path that was experienced in the developed nations and allow them to realize their economic development aspirations.

As the nation's leading consumer of coal, with an annual coal burn of over 80 million tons to produce reliable, affordable power for the millions of people and businesses we serve, AEP has been very active in the search for technological responses to the concerns about global climate change. In one such initiative, I served on the Steering Group for the Global Energy Technology Strategy Program, which was managed by Battelle. It is my understanding that this report provided the analytical basis for your legislation. The Battelle report concluded that "managing the risks of climate change will require a transformation in the production and consumption of energy. Technology is critical to such a transformation."

The *Climate Change Strategy and Technology Innovation Act* is inherently an expression of optimism and faith in our future. You forthrightly state that the problem is real and growing. Your bill provides the vision, the commitment, and the framework for the solution to this global commons problem. With U.S. leadership, we can illuminate the path the world must travel to stabilize greenhouse gases in the atmosphere and avert serious climatic changes. I truly hope that your bill will be expeditiously enacted into law, and that the Congress and the Administration will then provide the human and financial resources to turn your vision into a reality.

Sincerely,

E. R. Draper

E. Linn Draper, Jr.

TESTIMONY OF JONATHAN LASH
PRESIDENT, WORLD RESOURCES INSTITUTE

BEFORE SENATE GOVERNMENTAL AFFAIRS COMMITTEE

HEARINGS ON THE "CLIMATE CHANGE STRATEGY AND TECHNOLOGICAL INNOVATION ACT OF 2001," S. 1008

July 18, 2001

Mr. Chairman and Members of the Committee:

Thank you for inviting me to testify today. Among the many challenges facing our generation, none is more important than the threat of global warming. I commend you on your leadership in addressing this important issue.

By way of introduction, let me tell you a bit about the World Resources Institute. We are a private, non-profit, non-partisan, environmental think tank. We go beyond research to create practical ways to protect the Earth and improve people's lives. WRI convenes dialogues, builds partnerships, generates solutions and pursues cutting-edge research. We illuminate facts, dispel myths and bring our findings to policy-makers and the public at large. On issues including global warming, forest loss, marine biodiversity, the role of the public in environmental decision-making and the role of business in protecting the environment, we help shape the debate and get results that make a difference for the world as a whole.

For more than 15 years, WRI has been at the forefront of thinking on climate change. In 1984, WRI participated in groundbreaking international meetings on greenhouse warming and ozone depletion. During the next several years, WRI played a central role in organizing some of the first Congressional hearings on global warming. These hearings helped build Congressional support for early legislation including the National Energy Policy Act and Climate Protection Act of 1988. WRI was a leading instigator for the development of the Intergovernmental Panel on Climate Change (IPCC), and later helped organize the NGO community for steps leading up to the United Nations Conference on Environment and Development in Rio in 1992. WRI helped shape thinking of policymakers around the world in the run-up to the Kyoto conference in December 1997 and in the international negotiations that followed.

The foundation for the Institute's education and outreach on climate change has been a series of highly visible reports and policy briefs. With your permission, I would like to

submit several of our recent climate change policy briefs for the record. WRI also has a long and distinguished record working on issues related to climate change, such as energy pricing, transportation, and renewable energy. Recently, WRI has focused on reaching out to the business community building support for a more pro-active business stance on climate change. We have also developed innovative ways to use the Internet to address global warming, and invite you to visit our new website at www.safeclimate.net.

Mr. Chairman, today I'd like to say a few words about the threat of global warming, offer some specific thoughts on the legislation before us, and address the need for international action to address climate change.

1. THE THREAT OF GLOBAL WARMING

The conclusion of the world's scientists is quite unequivocal: climate change is real, we are beginning to see its consequences, and the emissions that cause it are increasing rapidly. Unless we change course, children born today will live to see greenhouse gas concentrations reach levels unknown on this planet for 40-50 million years – almost since the time of the dinosaurs. Such a rapid and unprecedented rise in greenhouse gas concentrations would likely bring devastating consequences, including more severe droughts and storms, sea-level rise, widespread forest loss, biotic disruptions, and the spread of tropical disease.

The basic physical processes behind the greenhouse effect are well known. Earth's atmosphere is made up of gases that trap the sun's rays and warm the planet. This trapped warmth maintains the Earth's average temperature at about 60 degrees F, allowing life on the planet as we know it. The main "greenhouse gases" (GHGs) added by human activity are carbon dioxide (CO2) and methane (CH4). Over the last 250 years the concentration of these gases has increased dramatically. Due to energy use, agriculture and forest loss, concentrations of CO2 have increased by nearly 30% and those of methane have more than doubled since 1750.

The increase in concentration of GHGs is causing fundamental physical changes in the atmosphere, oceans and the Earth's surface. The 1990s were the warmest decade in the last 1,000 years. Sea level is rising, precipitation patterns are changing, Arctic Sea ice is rapidly thinning, and glaciers are retreating worldwide. IPCC authors warn that projected warming is likely to increase the severity of the most damaging storms, and droughts.

Scientists are also beginning to see biological and ecosystem effects that had been predicted as a consequence of global climate change. Trees are budding a week or two sooner in the spring, birds have been laying eggs earlier, butterflies have moved up mountains and toward cooler polar regions. Many of the world's coral reefs are being destroyed by bleaching, in part because of warming ocean temperatures.

The severity of coming climate-change impacts will depend on the amount of greenhouse gas accumulation in the atmosphere. Current emissions of carbon dioxide would have to be cut by at least 60% to stabilize the *concentration* in the atmosphere at *current levels*

within the next century or two. If global *emissions* were stabilized at today's levels, the concentration of carbon dioxide would nevertheless almost double by 2100.

The U.S. Global Change Research Program (USGCRP) has just released "Climate Change Impacts on the U.S.", assuming mid-range emissions, previously published by IPCC in 1992, which makes no assumptions about international policy changes to reduce greenhouse gas emissions. Based on that study, in the U.S., sea-level rise is very likely to cause the loss of some barrier beaches, islands, marshes and coastal forests. Damage to water and sewer systems, transportation and communication infrastructure are likewise expected. While rare ecosystems and some species are likely to disappear, food supply and timber production are secure. Impacts on the water supply vary by region but drought will be a national concern.

Last month, the National Academy of Sciences released a report on the science of climate change commissioned by the White House a few months earlier. The Academy endorses the report from the USGCRP, as well the work of the IPCC more broadly. The Academy also states "Greenhouse gases are accumulating in the atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising."

Climate change is unlike the pollution problems we have dealt with in the past where the consequences were swift and clear, and the benefits of action were immediate. Americans felt the effects of unhealthy air, saw the effects of polluted water, and, when the pollution was stopped, they enjoyed benefits that were almost immediate.

However, the climate system has so much inertia that the changes set in motion by the buildup of greenhouse gases in the atmosphere will continue for hundreds of years after the buildup stops. Today's emissions will create the consequences that future generations will have to deal with, but will be unable to reverse. Species and ecosystems unable to adapt will disappear. Decades of work to save coral reefs, protect forest ecosystems, ensure freshwater supplies, improve humanity's health around the world, and build the infrastructure required for development will be at risk from climate change. One of the great achievements of the Twentieth Century was the creation of 44,000 parks and protected areas that include about 10 % of the dry land surface of the Earth. Most of those parks and protected areas, are at risk from climate change, because they cannot move as climate zones move.

All of this sounds pretty grim. But the good news is that effective policies to prevent climate change can set the world on a new course, one characterized by cleaner energy sources, healthier ecosystems, technological innovation and economic opportunity. We can meet the challenge of global warming – if we get started.

Let me repeat: We can meet the challenge of global warming – if we get started sooner, not later. That means measures to reduce emissions here in the United States, which is the world's largest emitter of greenhouse gases. It means working cooperatively with other nations. It means recognizing that climate change policies must be integrated with

policies related to energy and economic development. It means moving forward in a strategic manner, recognizing the gravity of the problem but realizing the many opportunities that arise from reducing greenhouse gas emissions here in the United States and around the world.

2. CLIMATE CHANGE STRATEGY AND TECHNOLOGICAL INNOVATION ACT OF 2001, S.1008

Let me now turn my attention to the bill before us today. I welcome S. 1008 and believe its introduction is a step forward in the dialogue on global warming.

Of course, as its sponsors recognize, S. 1008 is but a small part of the solution to global warming. As Senator Byrd said in introducing his legislation, S. 1008 "is intended to supplement, rather than replace, other complementary proposals to deal with climate change in the near term on both a national and international level." Most important, in my view, are the proposals to reduce greenhouse gas emissions in the United States, such as through limits on carbon dioxide as part of a comprehensive approach to power plant emissions. Mr. Chairman, S. 1008 makes a great deal of sense as a part of a package together with legislation requiring meaningful domestic action to reduce greenhouse gas emissions, but not as a substitute for action.

Several elements of S. 1008 show especial vision:

First, S.1008 recognizes that climate change represents an important threat the Nation's interests, and that we need a national climate change strategy informed by public dialogue. The strategy should take as its goal stabilization of greenhouse gases in the atmosphere at safe levels – the goal accepted by the United States now almost a decade ago when the first President Bush signed and the U.S. Senate ratified the Framework Convention on Climate Change. Unfortunately, the United States does not now have a strategy on climate change. As many commentators have noted, the Bush administration has stated clearly what it is against, but not offered any affirmative policy on this issue.

Second, S.1008 recognizes that climate change considerations must be infused into decision-making at every level in the U.S. government. I offer no view on the specific and highly detailed requirements set forth in the bill regarding the organization of the Executive Branch on the issue of climate change. I hope the bill's sponsors are open to further consultations on the details of their proposals in this regard. However the underlying purpose – to be sure that climate change receives priority attention in the executive branch decision-making – is one I wholeheartedly endorse.

Third, S. 1008 recognizes that "the economic consequences of...inaction" on global warming "may cost the global economy trillions of dollars." Too often those in the climate change debate focus exclusively on the cost of taking action to reduce emissions; S. 1008 properly recognizes that informed decision-making requires us also to consider the cost of inaction.

Fourth, S. 1008 recognizes that current research and development budgets are grossly inadequate to meet the challenge of climate change. As the bill's finding correctly state, "stabilization of greenhouse gases in the atmosphere will require transformational change in the global energy system" as well as "research and development that leads to bold technological breakthroughs." The bill also recognizes that additional commitment for this research must come from the public and private sectors. My own preference would be for increases significantly in excess of the doubling called for under the bill, but I believe the S. 1008 would have us move in the right direction.

Finally, S. 1008 recognizes that our national energy strategy cannot be shaped without close attention to the challenge of climate change. Treating climate change as an afterthought when energy policy is established is inconsistent with sound policy-making or the serious nature of the problem.

In summary, Mr. Chairman, I welcome S. 1008, congratulate its sponsors, and look forward to supporting its enactment as a complement to other legislation limiting domestic emissions of greenhouse gas emissions.

3. NEED FOR INTERNATIONAL ACTION

Finally, Mr. Chairman, I'd like to use this opportunity to speak briefly about the need for international action to address climate change. The topic is especially timely since, as we speak, more than 180 nations are gathering in Bonn, Germany for a conference of parties to the Framework Convention on Climate Change. Furthermore, according to news reports, global warming will be one of the most prominent topics of discussion when the leaders of the world's major industrial powers gather for the annual G-8 summit this weekend in Genoa, Italy.

Climate change is the quintessential global issue: emissions from one area of the globe affect the climate everywhere. Partly in recognition of this fact, in 1992 more than 180 nations negotiated the Framework Convention on Climate Change (FCCC). The FCCC was signed by the first President Bush and quickly ratified by the U.S. Senate. Among the important features of the FCCC are agreement on an objective -- to stabilize atmospheric concentrations of greenhouse gases at "a level that would prevent dangerous anthropogenic interference with the climate system." A few weeks ago President Bush noted that the parties to the Convention have not agreed on what level would be "dangerous". That is true, indeed the question has hardly been discussed, but we know that climate change *is* dangerous. We do not need to know the precise level that is unacceptably dangerous to begin to reduce emissions. The first ten years of the reduction strategy will be the same in any case.

The parties to the FCCC arrived at a second important agreement – that "developed country Parties should take the lead" in fighting climate change, and that countries should act in accordance with their "common but differentiated responsibilities and respective capabilities."

The developed country signatories also made a non-binding commitment to stabilize their GHG emissions to 1990 levels by the year 2000. By 1997, with emissions increasing

rapidly, it was clear that voluntary commitments had failed, and the 186 countries that have ratified the FCCC negotiated a binding agreement setting specific targets and timetables for emissions reductions by developed countries--the "Kyoto Protocol."

The Protocol, which the U.S. has signed but not ratified, would require the U.S. to reduce its emissions seven percent below 1990 levels by 2012. The U.S. successfully negotiated for the inclusion of so-called "flexibility mechanisms" in the Kyoto Protocol, including: the ability to count carbon sequestration (carbon absorbing activities such as planting trees, or changed agricultural practices) against emissions; international emissions trading among industrialized countries, and emissions trading with developing countries through the Clean Development Mechanism (which allows companies from the U.S. and elsewhere to claim credits for emission-reduction projects in developing countries).

Earlier this year, President Bush rejected the Kyoto Protocol, which he regards as unfair and unworkable. The reaction to this announcement from most of the rest of the world has been strongly negative. To date, President Bush has not said what type of international agreement, if any, he would support in the fight against global warming.

Mr. Chairman, although it may appear obvious, circumstances compel me to stress one key point: climate change is a global problem that requires a global solution. The current administration's unilateral rejection of years of work by the international community to address global warming is a clear and present danger to the climate system. Especially troubling is the administration's tendency to blame poorer nations for its own refusal to act.

As I said earlier, climate change is the quintessential global issue: emissions from one area of the globe affect the climate everywhere. However, neither emissions nor the impacts they cause are spread equally around the globe.

Although every country has emissions of CO_2, most of the emissions come from industrialized countries, and the United States with less than 5% of the world's population is responsible for 25% of emissions. Emissions from U.S. power plants alone exceed those from 146 countries with roughly 75% of the world's population. The emissions from India and China combined are 60% of those from the U.S., and the average American is responsible for 20 times the emissions of the average Indian, ten times the average Chinese.

Furthermore, countries differ in their vulnerability to climate change and in their capacity to adapt. Low-lying coastal areas, such as those of Bangladesh, and islands, such as those of the Pacific, face the greatest risks from rising sea levels and more severe storms. Although industrialized countries will also see serious consequences they are in a better position to protect, or rebuild infrastructure destroyed by storms, to adjust agricultural production to new conditions, or to avoid the spread of epidemics through adequate healthcare provision.

Despite profound North-South disparities, developing countries are actually already taking substantial actions to reduce emissions growth. China 's actions are the most remarkable. Even without quantitative commitments, the world's most populous country

reduced its emissions by 17 percent from 1997 to 1999. This is simply unprecedented—emissions have returned to 1992 levels, while China's economy has expanded by more than 90 percent over the same timeframe. How is this happening?

China began sweeping energy policy reforms in the early 1980s, to promote energy efficiency and conservation. Measures taken by China include reductions in fossil fuel subsidies; research, development and demonstration projects; a national information network with efficiency service and training centers; tax reforms; equipment standards; and special loan programs, among other initiatives. Without such measures, China's emissions would be at least 400 million tons higher than current levels, representing emission savings equal to nearly the entire U.S. transportation sector.

Today, more than two billion people around the world have no access to electric power, and another two billion have limited access to electric power and motorized transport. Their lives have little impact on warming, but warming will have a significant impact on them.

Mr. Chairman, the United States should show leadership on global warming, not blame poorer nations for inaction. If the United States remains an active and constructive part of negotiations over the form of a binding international agreement we will significantly shape the outcome. By refusing to take action domestically, and by failing to propose action internationally, we assure that we will either fail to influence the shape of international action, or prevent. Neither outcome is likely to benefit U.S. industries, or U.S. interests, let alone the well being of future generations. I earnestly hope the legislation you are considering here can become part of a constructive solution to this problem. Thank you again for opportunity to appear before you today.

AMERICAN COUNCIL FOR CAPITAL FORMATION

CONGRESSIONAL TESTIMONY

July 18, 2001

Tax Policy and Technological Innovation: Key Partners in Productive Climate Change Policy

Margo Thorning, Ph.D.
ACCF Senior Vice President and Chief Economist
Before the Senate Governmental Affairs Committee

EXECUTIVE SUMMARY

- **Macroeconomic Effects of Caps on CO_2 Emissions Are Significant.** A wide range of economic models predict that capping U.S. carbon dioxide (CO_2) emissions at the Kyoto target (7 percent below 1990 levels) would reduce U.S. GDP and slow wage growth significantly, worsen the distribution of income, and reduce growth in living standards. Proposed future reductions of 60 percent below 1990 levels by 2050 have not been modeled, but would have extremely serious consequences for all economies dependent on fossil fuels.
- **U.S. Budget Surplus Is Reduced Sharply.** Slower economic growth means that federal tax receipts would be reduced. If implementation of the Kyoto Protocol reduces annual GDP by 3 percent per year, for example, the projected budget surplus in 2010 falls from $471 billion to only $315 billion.
- **International Emissions Trading Issues Are Major.** Major obstacles to trading include securing developing country participation, allocating CO_2 emission rights, and distributing the resulting revenue.
- **European Union Unable to Meet Targets.** Even though several EU members continue to support ratification of the Kyoto Protocol, a number of recent studies document that the EU will not be able to achieve its targets; in fact by 2010 the EU countries will be 10 to 25 percent above their targets.
- **Science of Climate Change Needs to Be Better Understood Before Costly Policies Are Implemented.** Despite the United States' intensive investment in climate change science, numerous gaps remain in our knowledge, including conflict between global atmospheric and "surface" temperature measurement, and uncertainty about the amount of carbon sequestered in the oceans and soil and about the feedbacks in the climate system that determine the magnitude and rate of temperature increase.
- **Conclusion.** A U.S. strategy for a productive climate policy providing energy security should include: fixing the U.S. tax code; expanding nuclear energy; expanding bilateral cooperation with developing countries; expanding incentives for use of landfill methane and biomass including ethanol from cellulose; implementing a multi-year plan for improvement of coal technology; removing regulatory barriers; avoiding caps on CO_2 emissions by U.S. industry; and avoiding setting targets for global CO_2 concentrations in the range of 550 ppm in the next 75–100 years. ❖

The mission of the American Council for Capital Formation is to promote economic growth through sound tax, trade, and environmental policies. For more information about the Council or for copies of this testimony please contact the ACCF, 1750 K Street, N.W., Suite 400, Washington, D.C. 20006-2302; telephone: 202/293-5811; fax: 202/785-8165; e-mail: info@accf.org; Web site: www.accf.org.

ACCF STATEMENT

INTRODUCTION

My name is Margo Thorning and I am pleased to present this testimony to the Senate Governmental Affairs Committee.

The American Council for Capital Formation represents a broad cross-section of the American business community, including the manufacturing and financial sectors, Fortune 500 companies and smaller firms, investors, and associations from all sectors of the economy. Our distinguished board of directors includes cabinet members of prior Republican and Democratic administrations, former members of Congress, prominent business leaders, and public finance and environmental policy experts.

The ACCF is now celebrating its 28th year of leadership in advocating tax, regulatory, environmental, and trade policies to increase U.S. economic growth and environmental quality.

We commend Chairman Lieberman, Senators Byrd and Stevens and the Senate Governmental Affairs Committee for their focus on the role of technology in addressing climate mitigation. In our view, tax incentives should be a key component in the push to develop new technology. Given the ACCF's extensive studies on the impact of tax policy on investment, my testimony will develop an aspect of what should become the foundation for an integrated approach to climate change policy. We believe that progress on technology proposals such as those in S. 1008, the Climate Change Strategy and Technology Act of 2001, is vitally important.

My testimony begins with a review of the macroeconomic consequences of near-term CO_2 emission caps. It includes information from a number of analyses sponsored by the ACCF Center for Policy Research, the public policy research affiliate of the American Council for Capital Formation. These studies describe the economic costs of near-term caps on U.S. carbon emissions and the impact of emissions limits on the growth of the capital stock, as well as suggest tax incentives to encourage voluntary efforts such as the purchase of energy-efficient equipment and sequestration initiatives to reduce CO_2 emissions both in the United States and abroad. (Summaries of the Center's climate policy studies are available on our Web site, www.accf.org.) I also discuss issues related to long-term options for reducing CO_2 concentrations. Finally, strategies for a cost-effective, long-term approach to CO_2 stabilization are presented.

MACROECONOMICS EFFECTS OF CAPPING CO_2 EMISSIONS

The Kyoto Protocol to the United Nations Framework Convention on Climate Change, which was negotiated in December 1997, calls for industrial economies such as the United States, Canada, Europe, and Japan (termed Annex B countries) to reduce their collective emissions of six greenhouse gases by an average of 5.2 percent from 1990 levels by 2008–2012. The U.S. target under the Protocol, which was rejected by the Bush Administration in March, is a 7 percent reduction from 1990 levels (or 1,251 million metric tons); this amounts to a projected 536 million metric ton cutback in carbon emissions relative to the projected amount in 2010, growing to a 728 million metric ton cutback by 2020 (see Figure 1). In 1999, U.S. emissions were 1,527 million metric tons, or 22 percent above the Kyoto target. By 2010, the U.S. Department of Energy's Energy Information Administration (EIA) projects that emissions will be 43 percent above the target, and the gap will grow to 58 percent by 2020. (In 2010, carbon emissions from the transportation and utility sectors *alone* are projected to be 1,300 million metric tons (see Figure 1). It is also worth noting that Mr. Tim Wirth, the former Clinton Administration climate policy negotiator, testified in 1997 that carbon emissions would need to be cut by up to 10 times the Kyoto targets (a 70 percent reduction). The United Kingdom has assumed it must reduce its emissions by 60 percent by 2050.

The emissions cap would, in effect, ration the use of energy in the United States and require very large taxes, either directly or indirectly through the purchase of "permits," to restrain the demand for energy. The "multi-pollutant" approach would have the same effect. Research conducted over the past decade for the ACCF Center for Policy Research by top climate policy scholars concludes that the cost of reducing carbon emissions in the near term would impose a heavy burden on U.S. households, industry, and agriculture by reducing economic growth.

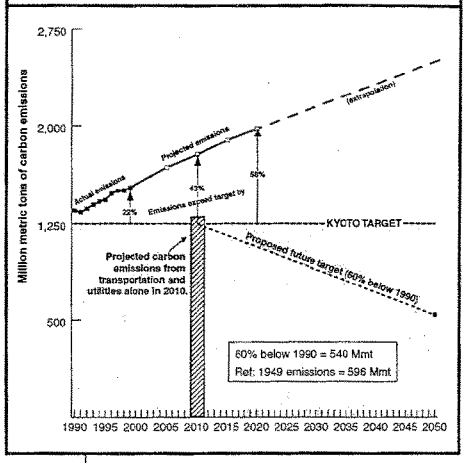
IMPACT ON GDP

Many climate policy experts believe that the emission reductions called for in the Kyoto agreement have potentially serious consequences for all Americans. Predicting the economic impact of reducing carbon

emissions depends upon how an economic forecasting model handles several factors, including how rapidly industry and consumers respond to higher energy prices by substituting less carbon-intensive production methods and reducing the consumption of carbon-intensive goods and services. Other factors that can affect a model's results are the rate of technological change, the projected baseline greenhouse gas emissions, the amount of emissions trading, and use of carbon sinks and sequestration.

The rate of technological improvement for energy production and consumption assumed by most models under their baseline forecasts is fairly rapid. For example, the EIA's reference case assumes continued improvements in new and existing buildings, transportation, coal production, exploration for oil and gas, and electricity generation technologies. In fact, total energy intensity (defined as the ratio of primary energy consumption per dollar of GDP) declines at an average rate of 1.1 percent annually between 1998 and 2020. The faster the rate of economic growth, the faster energy intensity declines in the EIA reference cases due to the more rapid turnover of the capital stock.

Figure 1 U.S. Carbon Emissions: Projected, Kyoto Target, and Beyond
Millions of metric tons



Recent model results show that as carbon emissions are capped or constrained, economic growth slows due to lost output as new energy taxes are imposed and prices rise for carbon-intensive goods—goods that must be produced using less carbon and/or more expensive processes. In addition, the capital stock accumulates more slowly, reflecting the premature obsolescence of capital equipment due to the sharp energy price increases required to meet the carbon emission reductions mandated under the Protocol. It takes from 20 to 30 years to "turn over" or replace the entire U.S. capital stock. Thus, meeting the Protocol's 2008–2012 timetable for emission reductions would mean either continuing to utilize plant and equipment designed to use much lower-cost (pre-Kyoto) fuels, or replacing the capital stock much more rapidly than its owners had planned.

The wide range of model results by climate policy experts such as Senior Vice President Mary H. Novak of WEFA, Inc., Professor Alan S. Manne of Stanford University, Dr. Richard Richels of EPRI, Dr. W. David Montgomery of Charles River Associates (CRA), Dr. Joyce Brinner of Standard & Poor's DRI (DRI), Dr. Brian S. Fisher of the Australian Bureau of Agricultural and Resource Economics (ABARE), and others, show that complying with the Kyoto Protocol would reduce U.S. GDP by a range of 1 percent to 4 percent annually (see Figure 2). This translates into annual losses of $100 billion to almost $400 billion (in inflation-adjusted dollars) in U.S. GDP each year compared to the baseline forecast for energy use. These studies, as well as the EIA report released in October 1998, stand in sharp contrast to the optimistic projections contained in the Clinton Administration's economic analysis prepared by the Council of Economic Advisers and released in July 1998.

Starting earlier to reduce carbon emissions (in 2000 rather than 2005) only worsens the overall impact, according to an EIA report released in July 1999. The EIA results show that the discounted present value of U.S. GDP falls by $1,430 billion 1992 dollars over the 2000–2020 period compared to $1,285 billion under the 2005 start date.

Economic Impact of Additional Reductions Beyond the Kyoto Target

The economic costs of the Kyoto Protocol described above do not reflect the additional economic impact of emission reductions beyond the Kyoto target. Kyoto supporters contemplate substantial future carbon emission reductions well below 1990 levels. At least one model has analyzed this scenario. A study using the Charles River Associates model (MS-MRT) shows that the cost of going beyond the carbon emission reductions required by the Kyoto Protocol is high. For example, a target of 21 percent below 1990 emission levels (or three times the Kyoto target) would reduce U.S. GDP by 2.4 percent annually in 2020 with Annex B emission trading and by 3.0 percent with domestic abatement alone.

Figure 2 Annual Impact of Reducing Carbon Emissions to the Kyoto Target on U.S. GDP, 2008–2012
Percent of GDP

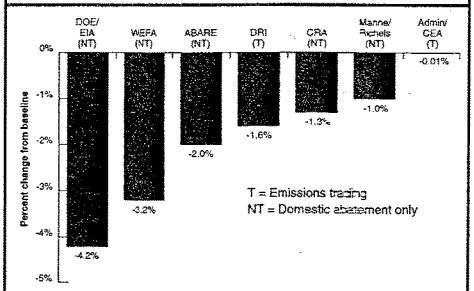


Figure compiled by Margo Thorning, Ph.D., ACCF Center for Policy Research, Washington, D.C., www.accf.org. Data source references can be found at the end of this report.

Impact on the Federal Budget Surplus

One way of assessing the impact of the Kyoto Protocol is to examine how slower economic growth would affect projected U.S. federal tax receipts and federal budget surpluses. Policymakers need to consider the potentially large negative impact of the Protocol on GDP growth and federal budget receipts, particularly since both the Administration and Congress are already chipping away at the federal budget surpluses to finance spending initiatives and tax cuts for fiscal year 2001 and beyond. Using a simple calculation based on the relationship of increases in GDP to federal tax receipts, if GDP is 3 percent lower annually, the on-budget surplus in 2010 would decline by $156 billion dollars, from $471 billion to $315 billion (see Figure 3). If, as the EIA model predicts, the Kyoto Protocol reduces GDP by 4 percent in 2010, the budget surplus drops to only $261 billion dollars.

Importance of International Emissions Trading

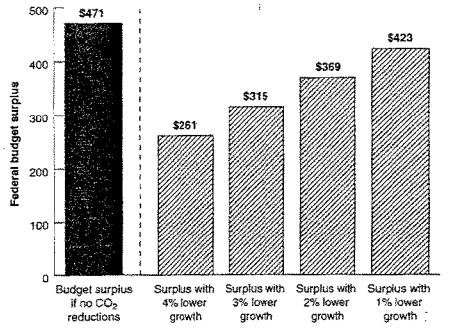
Numerous studies show that a major determinant of the cost of curbing emissions is whether the United States can purchase permits from abroad where emissions can be reduced at a lower cost than in the United States. In the absence of an unfettered international trading system, the United States would be forced to curb its own carbon emissions by about 30 percent within 10 years. Due to population growth and increases in output, the gap between projected emissions and the Kyoto target will continue to grow (see Figure 1). Neither this growing gap nor the impact of additional reductions beyond the Kyoto targets have been addressed by Kyoto advocates.

Impact on Wage Growth and Consumers

U.S. consumers suffer declines in wage growth and the distribution of income worsens under carbon stabilization policies. Wesleyan University Professor Gary Yohe estimates that reducing emissions to 1990 levels (the Clinton Administration's pre-Kyoto target) would reduce wage growth by 5 percent to 10 percent per year, and the lowest quintile of the population would see its share of the economic "pie" shrink by about 10 percent. Texas A&M University Professor John Moroney estimates that U.S. living standards would fall by 15 percent under the Kyoto Protocol compared to the base case energy forecast.

U.S. households also face much higher prices for energy under near-term reductions. A range of esti-

Figure 3 Reduction in Federal On-Budget Surplus in 2010 Due to Lower GDP Caused by Carbon Emission Reductions to the Kyoto Target
Dollars in billions



Note: "On-budget" surplus excludes Social Security and postal service contributions.

Calculations based on data from "An Analysis of the President's Budgetary Proposals for Fiscal Year 2002," Congressional Budget Office, May, 2001.

Figure 4 U.S. Household Energy Costs: Impact of Reducing Carbon Emissions to Kyoto Targets, 2008–2012
Percent change from base case

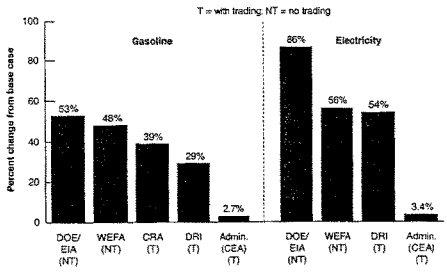


Figure compiled by Margo Thorning, Ph.D., ACCF Center for Policy Research, Washington, D.C., www.accf.org. Data source references can be found at the end of this report.

mates by various experts concludes that gasoline prices would rise from almost 30 percent to over 50 percent and that electricity prices would go up by anywhere from 50 percent over 50 percent (see Figure 4). Predictions by the Clinton Administration Council of Economic Advisers (a 2.7 percent increase in gasoline prices and 3.4 percent rise in prices for electricity) are far below those of widely respected climate policy modelers.

U.S. Competitiveness in Energy-Intensive Sectors and Agriculture

Several studies, including those by Dr. Brian Fisher and his colleagues at ABARE, University of Colorado's Professor Thomas Rutherford, DRI's Dr. Brinner, and WEFA's Ms. Novak, have concluded that near-term emission reductions would result in the migration of energy-intensive industry from the United States to non-Annex B countries (sometimes called "carbon leakage").

The 1999 study by Professor Manne of Stanford University and Dr. Richels of EPRI also analyzed this question. The Manne-Richels model results suggest that the Kyoto Protocol could lead to serious competitive problems for energy-intensive sector (EIS) producers in the United States, Japan, and CECD Europe. Meeting the emission targets in the Protocol would lead to significant reductions in output and employment among EIS producers, and there would be offsetting increases in countries with low energy costs. U.S. output of energy-intensive products such as autos, steel, paper, and chemicals could be 15 percent less than under the reference case by 2020. In contrast, countries such as China, India, and Mexico would increase their output of energy-intensive products. In its present form, the Protocol could lead to acrimonious conflicts between those who advocate free international trade and those who advocate a low-carbon environment, Professor Manne and Dr. Richels conclude.

U.S. agriculture would also lose competitiveness if the United States complied with the Kyoto Protocol. A study based on the DRI model by Terry Francl of the American Farm Bureau Federation, Richard Nadler of K.C. *Jones Monthly*, and Joseph Bast of the Heartland Institute (FNB) predicts that implementation of the Protocol would cause higher fuel oil, motor oil, fertilizer, and other farm operating costs. This would mean higher consumer food prices and greater demand for public assistance with higher costs. In addition, by increasing the energy costs of farm production in America while leaving them unchanged in developing countries, the Kyoto Protocol would cause U.S. food exports to decline and imports to rise. Reduced efficiency of the world food system could add to a political backlash against free trade policies at home and abroad.

The FNB analysis, which concludes that U.S. agriculture would be adversely affected by the Kyoto Protocol, stands in sharp contrast with the May 1999 report by the U.S. Department of Agriculture (USDA), which finds that the Kyoto Protocol would have "relatively modest" impacts on U.S. agriculture. The USDA report is seriously flawed for two reasons, according to a recent analysis by Mr. Francl. First, the USDA report relies on the unrealistic assumptions about the impact of the Kyoto Protocol on energy prices contained in the Administration's 1998 CEA analysis. Second, the USDA report makes the heroic assumption that U.S. farmers will have unrestricted access to carbon credit trading.

Flaws in the Clinton Administration CEA Analysis

The Clinton Administration Council of Economic Advisers' July 1998 economic analysis of the impact of reducing carbon emissions to 7 percent below 1990 levels, mentioned earlier, is seriously flawed for three reasons.

First, CEA cost estimates assume full global trading in tradable emission permits (including trading with China and India). Most top climate policy experts conclude that this assumption is extremely unrealistic, because the Protocol does not require developing nations—who will be responsible for most of the growth in future carbon emissions—to reduce their emissions, and many have stated that they will not do so.

Second, the CEA's cost estimates assume that an international carbon emissions trading system can be developed and operating by 2008–2012. This assumption is unrealistic, according to analysis by Massachusetts Institute of Technology's Professor A. Denny Ellerman.

Third, the cost estimates are based on the Second Generation Model (SGM) developed by Battelle Memorial Institute. The SGM appears to assume costless, instantaneous adjustments in all markets; the model is not appropriate for analyzing the Protocol's near-term economic impacts, according to CRA's Dr. Montgomery. As Massachusetts Institute of Technology Professor Henry Jacoby observes, there are no short-term technical changes that would significantly lower U.S. carbon emissions.

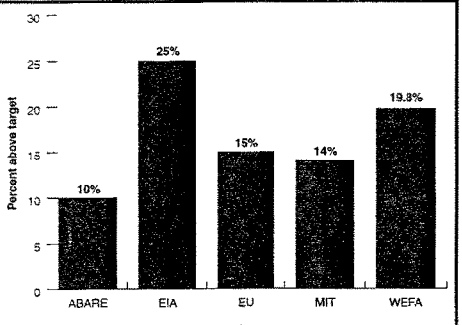
Finally, a former Clinton Administration official acknowledged that the CEA estimates understated the cost of the Kyoto Protocol by a factor of ten in a *USA Today* article (June 12, 2001).

European Union Unable to Meet Targets

Even though several EU members continue to support ratification of the Kyoto Protocol, a number of recent studies document that the EU will not be able to achieve its Kyoto CO_2 emission reduction targets by 2008–2012 (see Figure 5). These studies include:

- European Commission, "Towards a European Strategy for the Security of Energy Supply" (November 28, 2000). The EU's own report shows that their CO_2 emissions will be 15 percent above their Kyoto target by 2010, rising to almost 20 percent above by 2020. While stressing the need to reduce CO_2 emissions, the EU report cautions that climate change policy should not be allowed to "endanger economic development."
- The Pew Center on Global Climate Change, "The European Union & Global Climate Change" (June 2000). In an analysis of five major EU member states (Germany, United Kingdom, Netherlands, Austria, and Spain) responsible for 60 percent of CO_2 emissions in 1990, Pew concludes that only the United Kingdom has a good chance of meeting its targets and Germany will find it "difficult." The other three countries are "not on track"; emissions in the Netherlands currently exceed 1990 levels by 17 percent; Austria has no plans in place to meet its target; and Spain is already close to reaching its allowed growth in CO_2 emissions (a concession to its relative poverty), meaning that Spain is likely to be well above its emission target by 2010.

Figure 5 European Union CO_2 Emissions in 2010 Compared to the Kyoto Target, According to Recent Studies



Source: Figure compiled by Margo Thorning, Ph.D., ACCF Center for Policy Research, Washington, D.C., www.accf.org. Data source references can be found at the end of this report.

- MIT Joint Program on the Science and Policy of Global Change, "Carbon Emissions and the Kyoto Commitment in the European Union" (February 2001). According to the results of the MIT Emissions Prediction and Policy Analysis model, CO_2 emissions in the EU will rise by 14 percent above the 1990 levels in 2010 instead of decreasing by 8 percent as required by the Kyoto Protocol.
- The Australian Bureau of Agricultural and Resource Economics, "Climate Change Policy and the European Union" (September 2000). ABARE's report concludes CO_2 emissions in the EU will increase by an average of 0.3 percent per year from 1990 to 2010 unless stringent new measures are undertaken. (In other words, emissions will rise by about 10 percent rather than fall to 8 percent below 1990 levels).
- U.S. Department of Energy, Energy Information Administration, *International Energy Outlook* (March 2001). The EIA analysis predicts that by 2010, emissions in Western Europe will be almost 25 percent higher than they were in 1990, falling far short of their Kyoto targets.
- WEFA, "The Kyoto Protocol: Can Annex B Countries Meet Their Commitments?" (October 1999). WEFA surveys five other government reports, including an EU study (as well as its own analysis), and concludes that Western Europe is unlikely to meet its targets. Emissions would need to fall by 15 percent to 30 percent, which would constrain economic growth in politically unacceptable terms.

While a new European Commission report from the European Climate Change Programme (June 2001) analyzed measures affecting all sectors of their economy and concluded that "the potential of cost-effective options is twice the size of the EU's required emission reductions," the EU's new report is flawed for several reasons, including:

- "Cost-effective" is defined as policies that cost no more than 20 euros per metric ton of avoided CO_2 emissions, or $62 per metric ton of carbon in U.S. dollars. Most experts consider $62 per metric ton of carbon "expensive." (Some of the suggested policies cost up to $312 per metric ton of carbon to put in place.)
- The policy yielding the largest impact affects buildings. The costs of these policies was calculated with a very low discount rate (4 percent), a rate of return that no private investor would accept.

Thus, the new EU study is actually a "wish list" of policies the environmental ministry "wishes" that businesses and households would adopt, but that are not likely to be undertaken voluntarily because of their high costs.

Science of Climate Change Needs to Be Better Understood

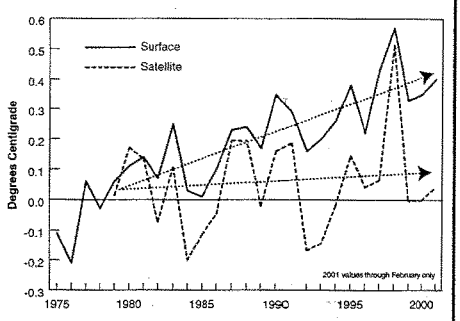
Despite the United States' intensive investment in climate change science over the past decade, numerous gaps remain in our understanding of climate change. The National Academy of Sciences' National Research Council identified critical uncertainties about the science of climate change in its white paper, *Climate Change Science: An Analysis of Some Key Questions:*

- Conflict between global atmospheric and "surface" temperature measurements (see Figure 6);
- Uncertainty about how much carbon is sequestered by oceans and terrestrial sinks and how much remains in the atmosphere;

- Uncertainty about feedbacks in the climate system that determine the magnitude and rate of temperature increases;
- Uncertainty about the direct and indirect effects of aerosols;
- Uncertainty about the details and impacts of regional climate change resulting from global climate change;
- Uncertainty about the nature and causes of the natural variability of climate, including the sun, and its interactions with forced changes;
- Uncertainty about the emissions and usage of fossil fuels and future emissions of methane.

These science questions must be addressed before the United States and its allies embark on a path as nonproductive as that of the Kyoto Protocol. (For more detail, please see the Appendix to this testimony.)

Figure 6 Surface vs. Satellite Global Temperatures



Source: John R. Christy, University of Alabama in Huntsville.

GREENHOUSE GAS EMISSION TARGETS PREMATURE AND UNJUSTIFIED

According to scholars such as Brookings Institution economist Dr. Robert Crandall, setting targets and timetables for U.S. greenhouse gas emissions is premature. He bases this conclusion on:

- The uncertainty about whether or the extent to which global warming is occurring (see Figure 6); new data from climatologist and U.N. Intergovernmental Panel on Climate Change author Professor John Christy of the University of Alabama demonstrates that while surface-based measures show warming, satellite data shows little warming; and
- The high cost of foregone investment if the United States sacrifices badly needed economic growth to reduce emissions.

In a 1999 report, Dr. Crandall observes that the economic estimates of the costs and benefits of reducing emissions to 1990 levels that are in the literature are not particularly supportive of going ahead immediately with any policy of abatement. For example, as an analysis by Brookings Institution fellows Drs. Warwick McKibben and Peter Wilcoxen points out, the estimates of the costs of capping emissions at 1990 levels generally range from 1 to 2 percent of GDP per year, while the benefits, estimated at most to be 1.3 percent of GDP, will not arise for at least 30 to 50 years. Dr. Crandall notes that "Every dollar dedicated to greenhouse gas abatement *today* could be invested to grow into $150 in the next 50 years at a 10 percent social rate of return, even at a puny 5 percent annual return, each dollar would grow into $12 in 50 years. Therefore, we need to be sure that the prospective benefits, when realized, are at least 12 to 150 times the current cost of securing them. Otherwise, we should simply not act, but use our scarce resources in other ways." Moreover, the climate models generally forecast that it would require far greater reductions than a return to 1990 emissions to stabilize the climate. Dr. Crandall concludes, "We cannot justify a return to 1990 emissions based on the average estimates in the literature, no matter how efficiently it is done."

It is clear that the marginal costs of abatement in low-income societies such as China and India are substantially below those in developing countries, Dr. Crandall notes. Economists envision a marketable permits program as being global in scope. The United States, France, Japan, and Germany, for example, would buy permits from China, India, or Bangladesh. The latter would, in turn, reduce their CO_2 or other greenhouse gas emissions by this amount over the levels that would have occurred without the permits policy in all future years. The difficulties involved in such a future program would be immense: measuring emissions from millions of sources from motor scooters to

bovine animals; forecasting emission levels for the uncontrolled scenario; and, finally, enforcing the reductions from these myriad sources. If enforcing nuclear nonproliferation treaties is difficult, enforcing a global greenhouse gases trading program would be incomparably more complicated.

Yale University Professor William D. Nordhaus has also analyzed the costs and benefits of CO_2 emission limits. Dr. Nordhaus' research shows that the costs of even an efficiently designed emission reduction program exceed the value of environmental benefits by a ratio of 7 to 1 and that the United States would bear almost two-thirds of the global cost.

Targets and timetables for emission reductions would also tend to discourage businesses and households from investing now in new equipment and processes that would reduce greenhouse gas emissions. This unfortunate result stems from the fact that tax depreciation schedules for many types of investments that could reduce CO_2 emissions are very slow. Slow capital cost recovery means that investments that are deemed "risky" because of possible future emission caps face a much higher hurdle rate to gain acceptance than would an investment whose cost could be recouped immediately through expensing (first-year write-off). The prospect of emission constraints in the future will tend to retard the very type of capital expenditures that many believe would facilitate emission reductions without curtailing economic growth.

Table 1 International Comparison of the Present Value of Pollution Control Equipment
As a percent of cost

	Wastewater Treatment for Chemical Production	Wastewater Treatment for Pulp and Paper Equipment	Scrubbers Used in Electricity Plants
United States			
1985 Law	100.1	100.1	89.7
MACRS[1]	85.2	80.8	54.5
AMT[2]	83.0	78.0	54.5
Brazil	74.7	74.7	79.4
Canada	85.3	85.3	85.3
Germany	71.8	69.7	68.9
Japan	84.6	83.7	82.4
Korea (w/3% ITC)	95.2	93.9	92.2
Singapore	91.7	91.7	91.7
Taiwan	147.0	147.0	147.0

Notes: 1. MACRS = Modified Accelerated Cost Recovery System (current law) for regular taxpayers included in TRA '86.
2. AMT = Alternative minimum tax (current law, Taxpayer Relief Act of 1997).

Source: Stephen R. Corrick and Gerald M. Godshaw, "AMT Depreciation: How Bad Is Bad?" in *Economic Effects of the Corporate Alternative Minimum Tax* (Washington, D.C.: American Council for Capital Formation Center for Policy Research, September 1991); and unpublished data incorporating the AMT provisions of OBRA 1993. Updated by Arthur Andersen LLP, Office of Federal Tax Services, Washington, D.C., January, 1998.

Tax Policy for Voluntary Action

Current U.S. tax policy treats capital formation—including investments that increase energy efficiency and reduce pollution—harshly compared with other industrialized countries and with our own recent past. For example, before the 1986 Tax Reform Act (TRA '86), the United States had one of the best capital cost-recovery systems in the world.

Under the strongly pro-investment tax regime in effect during 1981–85, the present value of cost-recovery allowances for wastewater treatment facilities used in pulp and paper production was about 100 percent (meaning that the deductions were the equivalent of an immediate write-off of the entire cost of the equipment), according to an analysis by Arthur Andersen LLP (see Table 1).

Under TRA '86, the present value for wastewater treatment facilities fell to 81 percent for pulp and paper, dropping the U.S. capital cost recovery system to near the bottom ranking of an eight-country international survey. Allowances for scrubbers used in the production of electricity were 90 percent before TRA '86; the present value fell to 55 percent after TRA '86, ranking the United States at the bottom of the survey. As is true in the case of productive equipment, both the loss of the investment tax credit and the lengthening of depreciable lives enacted in TRA '86 raised effective tax rates on new investment in pollution-control and energy-efficient equipment. Slower capital cost recovery means that equipment embodying new technology and energy efficiency will not be put in place as rapidly as it would be under a more-favorable tax code. A variety of tax incentives such as expensing, accelerated depreciation, tax-exempt bond financing,

or more-generous loss carrybacks that reduce the cost of capital for voluntary efforts to reduce greenhouse gas emissions, such as those included in S. 1777, the Climate Change Tax Amendment introduced in the 106th Congress by Senator Larry Craig (R-ID), would be more effective than the "credit for early action" regulatory framework proposal or the multi-pollutant approach proposed by some in Congress.

Conclusions: A Partnership Between Tax Policy and Technological Innovation

If, as knowledge of the climate system increases, policy changes to reduce carbon emissions become necessary, these changes should be implemented in a way that minimizes damage to the U.S. economy. Above all, experts agree that voluntary measures clearly and cost-effectively reduce the growth in greenhouse gas emissions, as the U.S. Second National Communication to the Framework Convention on Climate Change noted in 1997.

A U.S. strategy for reducing CO_2 emissions and providing energy security should include:

- **Fix the U.S. Tax Code:** Providing expensing (first-year write-off) or faster depreciation for new investments that reduce CO_2 can reduce the cost of capital by 20–30 percent.
- **Expand Nuclear Energy:** Nuclear power expansion has a vital role to play in managing CO_2 emissions while strengthening U.S. energy security.
- **Expand Bilateral Cooperation With Developing Countries:** Promoting the use of existing and emerging technology in developing countries for clean coal, natural gas, and hydro electricity production could substantially slow the growth of global CO_2 emissions.
- **Expand Incentives for use of landfill methane and biomass** including ethanol from cellulose. The EIA's April 2000 Climate Change Technology Initiative report shows that these programs are the most efficient use of tax incentives to reduce CO_2 emissions.
- **Implement Multi-Year Plan for Improvement of Coal Technology:** In the short term, focus on new clean coal technology, co-firing with biomass, and coal to gas; in the long term, institute a capture target of 50 percent (converts coal emissions to the equivalent of natural gas).
- **Remove Regulatory Barriers:** New Source Review is impeding the retrofitting and expansion of U.S. electricity generating, refining, and manufacturing capacity and making it more difficult to put in place the kinds of changes that would reduce CO_2 for each unit produced.
- **Avoid Caps on CO_2 Emissions** by U.S. industry. Such a policy will have a negative impact on the willingness of industry to invest here in the United States in the new technologies because of the concern that "voluntary" emission cuts will become mandatory. Allowing industry to recover its costs faster will spur the kind of investments that reduce CO_2 and expand output of energy as well as other products and services.
- **Avoid Setting Targets for Global CO_2 Concentrations** in the range of 550 ppm in the next 75–100 years. Such targets would require the developed countries' CO_2 emissions to fall to zero by about 2050 and would likely severely constrain U.S. economic growth. Models which show that their targets can be achieved at low cost, such as the Second Generation Model used by Jae Edmonds at Battelle Memorial Institute, are seriously flawed. The SGM model assumes costless, instantaneous adjustments in all markets and does not specify how the new technology required to move off carbon-based fuels is to be developed.

The consensus of the noted climate policy scholars whose work is discussed in this report is clear. Given the need to maintain strong U.S. economic growth to address such challenges as a growing population, the retirement of the baby boom generation, and a persistent trade deficit, policymakers need to weigh carefully the Kyoto Protocol's negative economic impacts and its failure to engage developing nations in full participation. Adopting a thoughtfully timed climate change policy—based on accurate science, improved climate models, global participation, tax incentives to accelerate investment in energy efficiency and sequestration, and new technology—is essential, both to U.S. and global economic growth and to eventual stabilization of the carbon concentration in the atmosphere, if growing scientific understanding indicates such a policy is needed. ❖

Sources and Additional Reading

Data Sources, Figures 2 & 4

DOE/EIA: U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting.

1998 (October). Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity. Washington, D.C.

WEFA: Novak, Mary H. 1998. Global Warming: The High Cost of the Kyoto Protocol—National and State Impacts. Eddystone, Penn.: WEFA, Inc.

ABARE (Australian Bureau of Agricultural and Resource Economics): Tulpulé, Vivek, Stephen Brown, Jaekyu Lim, Cain Polidano, Hom Pant, and Brian S. Fisher. 1999. The Kyoto Protocol: An Economic Analysis Using GTEM. *The Energy Journal* (Special Issue: The Costs of the Kyoto Protocol) 257–286.

DRI (Standard & Poor's DRI): Brinner, Joyce Y. 1999. Commentary: The Impact of Meeting the Kyoto Protocol on Energy Markets and the Economy. In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 63–72. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

CRA (Charles River Associates): Bernstein, Paul M., W. David Montgomery, Thomas F. Rutherford, and Gui-Fang Yang. 1999. Effects of Restrictions on International Permit Trading: The MS-MRT Model. *The Energy Journal* (Special Issue: The Costs of the Kyoto Protocol) 221–256.

Manne/Richels: Manne, Alan S. and Richard G. Richels. 1999. The Kyoto Protocol: A Cost-Effective Strategy for Meeting Environmental Objectives? In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 3–23. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Admin/CEA: Council of Economic Advisers. 1998 (July). The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis.

Report Sources

ACCF Center for Policy Research. 2000. *The Kyoto Commitments: Can Nations Meet Them With the Help of Technology?* Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Australian Bureau of Agricultural and Resource Economics. 2000 (September). Climate Change Policy and the European Union. www.abareconomics.com

Bernstein, Paul M., and W. David Montgomery. 1998. How Much Could Kyoto Really Cost? A Reconstruction and Reconciliation of Administration Estimates. Washington, D.C.: Charles River Associates.

Bernstein, Paul M., W. David Montgomery, Gui-Fang Yang, Thomas F. Rutherford, and James L. Sweeney. 1998. Trade and Industry Impacts of the Kyoto Protocol. Washington, D.C.: The Business Roundtable.

Bernstein, Paul M., W. David Montgomery, Thomas F. Rutherford, and Gui-Fang Yang. 1999. Effects of Restrictions on International Permit Trading: The MS-MRT Model. *The Energy Journal* (Special Issue: The Costs of the Kyoto Protocol) 221–256.

Brinner, Joyce Y. 1999. Commentary: The Impact of Meeting the Kyoto Protocol on Energy Markets and the Economy. In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 63–72. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Business Roundtable. 2001 (April). Unleashing Innovation: The Right Approach to Global Climate Change. White Paper. Washington, D.C.

Climate Action Report. 1997. Second national communication submitted to the Framework Convention on Climate Change by the United States. Washington, D.C.: U.S. Department of State.

Council of Economic Advisers. 1998 (July). The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis.

Crandall, Robert. 1997. Economists and the Global Warming Debate. In Jonathan Adler, ed., *The Costs of Kyoto*. Washington, D.C.: Competitive Enterprise Institute.

Ellerman, A. Denny. 1999. Obstacles to Global CO_2 Trading: A Familiar Problem. In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

European Climate Change Programme. 2001 (June). Report. http://europa.eu.int/comm/environment/climat/eccp.htm.

European Commission. 2000 (November). Towards a European Strategy for the Security of Energy Supply.

Francl, Terry, Richard Nadler, and Joseph Bast. 1999. The Kyoto Protocol and U.S. Agriculture. Heartland Policy Study No. 87. Chicago: The Heartland Institute.

Gummer, John, and Robert Moreland. 2000 (June). The European Union and Global Climate Change: A Review of Five National Programmes. Arlington, Virginia: Pew Center on Global Climate Change.

Jacoby, Henry D. 1999. The Uses and Misuses of Technology Development as a Component of Climate Policy. In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 151–169. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Jotzo, Frank, Edwina Heyhoe, Kate Woffenden, Stephen Brown, and Brian S. Fisher. 2000. Commentary: The Kyoto Protocol—Impact on Developing Countries and Some Implications for the Design of the Kyoto Mechanisms. In *The Kyoto Commitments: Can Nations Meet Them With the Help of Technology?*, 75–107. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Manne, Alan S. and Richard G. Richels. 1999. The Kyoto Protocol: A Cost-Effective Strategy for Meeting Environmental Objectives? In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 3–23. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

McKibben, Warwick j., and Peter J. Wilcoxen. 1997. A Better Way to Slow Global Climate Change. Brookings Policy Brief No. 17. Washington, D.C.: Brookings Institution.

Montgomery, W. David. 1996. Developing a Framework for Short- and Long-Run Decisions on Climate Change Policies. In *An Economic Perspective on Climate Change Policies*, 15–43. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Moroney, John R. 1999. Energy, Carbon Dioxide Emissions, and Economic Growth. In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality*, 41–62. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

National Academy of Sciences, Committee on the Science of Climate Change, National Research Council. 2001. *Climate Change Science: An Analysis of Some Key Questions*. Washington, D.C.: National Academy Press.

Nordhaus, William and Joseph Boyer. 1999. Requiem for Kyoto: An Economic Analysis. In *The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, ed. John P. Weyant. *The Energy Journal*, Special Issue.

Novak, Mary H. 1998. Global Climate Change, Environmental Quality, and U.S. Living Standards: The Impact on Consumers. In *The Impact of Climate Change Policy on Consumers: Can Tradable Permits Reduce the Cost?*, 3–18. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Novak, Mary H. 2000. The Kyoto Protocol: Can Annex B Countries Meet Their Commitment? In *The Kyoto Commitments: Can Nations Meet Them With the Help of Technology?*, 13–66. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Novak, Mary H. 1998. Global Warming: The High Cost of the Kyoto Protocol—National and State Impacts. Eddystone, Penn.: WEFA, Inc.

Rutherford, Thomas. 1996. Carbon Dioxide Emission Restrictions in the Global Economy: Leakage, Competitiveness, and the Implications for Policy Design. In *An Economic Perspective on Climate Change Policies*, 203–222. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

Tulpulé, Vivek, Stephen Brown, Jaekyu Lim, Cain Polidano, Hom Pant, and Brian S. Fisher. 1999. The Kyoto Protocol: An Economic Analysis Using GTEM. *The Energy Journal* (Special Issue: The Costs of the Kyoto Protocol) 257–286.

U.S. Department of Agriculture. 1999 (May). Economic Analysis of U.S. Agriculture and the Kyoto Protocol. Washington, D.C.

U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting. 2001 (March). *International Energy Outlook*. Washington, D.C.

U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting. 2000 (December). *Annual Energy Outlook 2000*. Washington, D.C.

U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting. 2000 (April). Analysis of the Climate Change Technology Initiative. Washington, D.C.

U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting. 1999 (July). Analysis of the Impacts of an Early Start for Compliance with the Kyoto Protocol. Washington, D.C.

U.S. Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting. 1998 (October). Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity. Washington, D.C.

Viguier, Laurent L., Mustafa H. Babiker, and John M. Reilly. 2001 (February). Carbon Emissions and the Kyoto Commitment in the European Union. Report No. 70. Cambridge, Mass.: MIT Joint Program on the Science and Policy of Global Change.

Yohe, Gary W. 1997. Climate Change Policies, the Distribution of Income, and U.S. Living Standards. In *Climate Change Policy, Risk Prioritization, and U.S. Economic Growth*, 13–54. Washington, D.C.: American Council for Capital Formation Center for Policy Research.

APPENDIX: KEY GAPS IN THE SCIENCE OF CLIMATE CHANGE

Despite the United States' intensive investment in climate change science over the past decade, numerous gaps remain in our understanding of climate change. The National Academy of Sciences' National Research Council identified in its June 2001 white paper, *Climate Change Science: An Analysis of Some Key*, critical uncertainties about the science of climate change.

The National Research Council paper goes on to identify a range of specific areas of scientific uncertainty that require additional study and research. These gaps include (page references are from the source document):

■ **Conflict exists between global atmospheric and "surface" temperature measurements:**

"Although warming at the Earth's surface has been quite pronounced during the past few decades, satellite measurements beginning in 1979 indicate relatively little warming of air temperature in the troposphere [see Figure 6 in this testimony]. ... The finding that surface and troposphere temperature trends have been as different as observed over intervals as long as a decade or two is difficult to reconcile with our current understanding of the processes that control the vertical distribution of temperature in the atmosphere." **(p. 17)**

■ **How much carbon is sequestered by oceans and terrestrial sinks and how much remains in the atmosphere are uncertain:**

"How land contributes, by location and processes, to exchanges of carbon with the atmosphere is still highly uncertain..." (p. 11)

"These estimates [of future carbon dioxide climate forcings] ... are only approximate because of uncertainty about how efficiently the ocean and terrestrial biosphere will sequester atmospheric CO_2." (p. 13)

"How much of the carbon from future use of fossil fuels will be seen as increases in carbon dioxide in the atmosphere will depend on what fractions are taken up by land and by the oceans. The exchanges with land occur on various time scales, out to centuries for soil decomposition in high latitudes, and they are sensitive to climate change. Their projection into the future is highly problematic." (p. 18)

■ **The feedbacks in the climate system that determine the magnitude and rate of temperature increases are uncertain:**

"Because there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments (either upward or downward)." (p. 1)

"Much of the difference in predictions of global warming by various climate models is attributable to the fact that each model represents these [feedback] processes in its own particular way. These uncertainties will remain until a more fundamental understanding of the processes that control atmospheric relative humidity and clouds is achieved." (p. 4)

"The warming that has been estimated to have occurred in response to the buildup of greenhouse gases in the atmosphere is somewhat greater than the observed warming." (p. 17)

■ **The direct and indirect effects of aerosols are uncertain:**

"The greatest uncertainty about the aerosol climate forcing—indeed, the largest of all the uncertainties about global climate forcings—is probably the indirect effect of aerosols on clouds." (p. 14)

"The great uncertainty about this indirect aerosol climate forcing presents a severe handicap both for the interpretation of past climate change and for future assessments of climate changes." (p. 14)

"Climate forcing by anthropogenic aerosols is a large source of uncertainty about future climate change." (p. 13)

"Because of the scientific uncertainties associated with the sources and composition of carbonaceous aerosols, projections of future impacts on climate are difficult." (p. 12)

"The conclusion is that the black carbon aerosol forcing is uncertain but may be substantial. Thus there is the possibility that decreasing black carbon emissions in the future could have a cooling effect that would at least partially compensate for the warming that might be caused by a decrease in sulfates." (p. 13)

■ **The details and impacts of regional climate change resulting from global climate change are uncertain:**

"On the regional scale and in the longer term, there is much more uncertainty" with respect to effects on agriculture and forestry. (p. 19)

"The Northern Hemisphere as a whole experienced a slight cooling from 1946–75, and the cooling during that period was quite marked over the eastern United States. The cause of this hiatus in the warming is still under debate." (p. 16)

"Health outcomes in response to climate change are the subject of intense debate. ... The understanding of the relationships between weather/climate and human health is in its infancy and therefore the health consequences of climate change are poorly understood. The costs, benefits, and availability of resources for adaptation are also uncertain." (p. 20)

"Changes in storm frequency and intensity are one of the more uncertain elements of future climate change prediction." (p. 20)

■ **The nature and causes of the natural variability of climate, including the sun, and its interactions with forced changes are uncertain:**

"Because of the large and still uncertain level of natural variability inherent in the climate record and the uncertainties in the time histories of the various forcing agents (and particularly aerosols), a causal linkage between the buildup of greenhouse gases in the atmosphere and the observed climate changes during the 20th century cannot be unequivocally established." (p. 17)

The value of indirect effect of ozone changes induced by solar ultraviolet irradiance variations "remains highly uncertain." (p. 14)

■ **The emissions and usage of fossil fuels and the future emissions of methane are uncertain:**

"The increase of global fossil fuel CO_2 emissions in the past decade, averaging 0.6 percent per year, has fallen below the IPCC scenarios. The growth of atmospheric CH_4 has fallen well below the IPCC scenarios." (p. 19)

"With a better understanding of the sources and sinks of methane, it may be possible to encourage practices ... that lead to a decrease in atmospheric methane and significantly reduce future climate change." (p. 13)

"There is no definitive scientific basis for choosing among several possible explanations for these variations in the rates of change of global methane contributions, making it very difficult to predict its future atmospheric concentrations." (p. 11)

In response to these gaps in our knowledge, the NRC paper also recommends "research that couples physical, chemical biological and human systems; an improved capability of integrating scientific knowledge, including its uncertainty, into effective decision support systems, and an ability to conduct research at the regional or sectoral level that promotes analysis of the response of human and natural systems to multiple stresses."

The NRC study also indicates that to advance the understanding of climate change, it will be necessary to have "a global observing system in support of long term climate monitoring and prediction [and] concentration on large-scale modeling through increased, dedicated supercomputing and human resources." In addition to the recent NRC paper, the U.S. Global Change Research Program has updated its 10-year plan and submitted it to the National Research Council (NRC) for review. High priority areas for further research are identified in numerous recent reports and documents, such as:

- "Global Environmental Change: Research Pathways for the Next Decade" (NRC, 1998);
- "Capacity of U.S. Climate Modeling to Support Climate Change Assessment Activities" (NRC, 1998); and
- "Adequacy of Climate Observing Systems" (NRC, 1999).

need to put a highly qualified teacher in every classroom in each school in which 50 percent or more of the children are from low income families, over the next 4 years;

(2) provide 125,000 new teachers with mentors and year-long supervised internships; and

(3) provide high quality pedagogical training for every teacher in every school.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to carry out title II Part A of the Elementary and Secondary Education Act of 1965—

(1) $3,500,000,000 for fiscal year 2003;
(2) $4,000,000,000 for fiscal year 2004;
(3) $4,500,000,000 for fiscal year 2005;
(4) $5,000,000,000 for fiscal year 2006;
(5) $5,500,000,000 for fiscal year 2007;
(6) $6,000,000,000 for fiscal year 2008.

MORNING BUSINESS

Mr. JEFFORDS. Mr. President, I ask unanimous consent that there now be a period for morning business, with Senators permitted to speak for up to 10 minutes each.

The PRESIDING OFFICER. Without objection, it is so ordered.

Mr. JEFFORDS. Mr. President, I suggest the absence of a quorum.

The PRESIDING OFFICER. The clerk will call the roll.

The assistant legislative clerk proceeded to call the roll.

Mr. DODD. Mr. President, I ask unanimous consent that the order for the quorum call be rescinded.

The PRESIDING OFFICER. Without objection, it is so ordered.

Mr. DODD. Mr. President, is morning business the pending business?

The PRESIDING OFFICER. The Senator is correct, with a 10-minute limitation.

Mr. DODD. I gather our colleague and friend from West Virginia may be here shortly, as he is inclined to do on Fridays for periods of enlightenment. I encourage Members to listen carefully to the distinguished senior Senator from West Virginia. He always has the most interesting discussions on history and poetry and important national holidays and days of recognition. It is worthy of the Senate's attention for those who may be following the debate through the channels of public communication.

Mr. BYRD. Mr. President, I ask unanimous consent to speak out of order for as long as is necessary, and it will not be all that long, but long enough.

The PRESIDING OFFICER. Without objection, it is so ordered.

THE FUTURE COURSE OF THE INTERNATIONAL CLIMATE CHANGE NEGOTIATIONS

Mr. BYRD. Mr. President, earlier this week, Vice President CHENEY gave us a brief glimpse of the administration's soon-to-be-released energy plan that suggests that we need to take action to avert an impending energy crisis. He suggested that the plan will push for increasing fuel supplies from domestic sources. Still, the Vice President did not explain how domestic climate change programs will be reflected in the energy plan, nor did he discuss press reports that the administration is developing a plan to deal with the international aspects of climate change.

I would like to focus on the latter, and discuss recent decisions by the administration regarding the international negotiations. Climate change cannot be discussed in complete isolation from the soon-to-be released energy plan, since the issue of climate change must be addressed both domestically and internationally.

I wish to note, at the outset, that I applaud the administration's support for clean coal technologies and the administration's recognition that coal is one of our country's most important sources of energy. I recognize and strongly support this policy by the executive branch. A bill I have introduced this session, S. 60, the National Electricity and Environmental Technology Act, addresses the challenges faced by coal, and I would welcome the administration's active support to utilize coal in a cleaner, more efficient way.

I also believe, however, that it would be a mistake to focus too heavily just on increasing fuel supplies from domestic sources. If that is where the administration is headed, it is not on exactly the right path. In order to solve the challenge of climate change, we must develop new domestic sources such as coal, using clean coal technologies, while also engaging in bold initiatives to develop new technologies in the area of energy conservation, energy efficiency, and renewable energy.

I am concerned, based upon preliminary reports, that the administration's plan may not reflect such a balanced and farsighted perspective. Let me begin by noting the obvious—the primary, manmade cause of global warming is the burning of the very fossil fuels that power virtually the entire world.

Here is part of the power just above us as we look up to the ceiling of the Senate Chamber and see these lights. What is required, then, is the equivalent of an industrial revolution. We must develop new and cleaner technologies to burn fossil fuels as well as new methods to capture and sequester greenhouse gases, and we must develop renewable technology that is practical and cost-effective. Rarely has mankind been confronted with such a challenge—a challenge to improve how we power our economy. This is the greatest nation in the world when the issue is one of applying our engineering talents to push beyond the next incremental improvement, and, instead, visualize and then achieve major leaps forward. We can do this, if only we apply ourselves. The scale and the scope of the problem are enormous, as is the leadership that will be required by the current administration, and, for that matter, the next dozen administrations, if we are to confront and overcome this awesome challenge in our children's time and in our grandchildren's lifetime.

But this takes visionary leadership. It would take extraordinary leadership. We need more than just small, incremental increases in our domestic oil supplies or in our existing research and development programs. This is an approach which only pays lip service to the challenge that we face. It is a huge challenge. I hope that the administration's plan will take a broader view.

We must also recognize that the European Union, China, and other developing nations are quick to point the finger at us, at the world's largest contributor to global warming. We must demonstrate our resolve, and begin to get our own house in order by launching such a research and development effort, as well as continuing and expanding our current efforts to reduce our greenhouse gas emissions.

However, it should also be noted that China will soon surpass us as the largest emitter of greenhouse gases. The Chinese Government must stop blocking all forward movement on the question of developing country participation. The developing world is poorly served by the current level of Chinese intransigence. The poorest nations in the developing world—which will be those that are hardest hit by global warming during this century—must demand leadership from within their own ranks, and especially from China. The Chinese leadership must join us in honestly discussing solutions to the problem of climate change. The United States can develop and provide the technological breakthroughs that can be deployed by all nations, as we move forward together to solve this common, global problem.

However, I want to emphatically warn that new technologies and voluntary approaches will not by themselves solve this problem. We must also actively negotiate and ratify international agreements that include binding commitments for all of the largest emitters of greenhouse gases, if we are to have any hope of solving one of the world's—one of humanity's—greatest challenges.

This concern takes me back to the Senate's actions just 4 years ago. During the Senate floor debate over Senate Resolution 98 in July 1997, I expressed two fundamental beliefs that have guided my approach on the issue of climate change. First, while some scientific uncertainties remain, I believe that there is significant, mounting evidence that mankind is altering the world's climate. Second, the voluntary approach of the 1992 United Nations Framework Convention on Climate Change, commonly known as the Rio Convention, has failed, as almost all of the nations of the world, including the United States, have been unable to meet their obligations to reduce greenhouse gas emissions to 1990 levels. With those points in mind, we must ask

what needs to be done in a binding fashion to begin to address this global issue—the preeminent environmental challenge of our time.

On July 25, 1997, the Senate passed, by a vote of 95–0, S. Res. 98 which stated that, first, developing nations, especially the largest emitters, must agree to binding emission reduction commitments at the same time as industrialized nations and, second, any international climate change agreement must not result in serious harm to the U.S. economy. That resolution served as guidance to U.S. negotiators as they prepared to hammer out the details of the Kyoto Protocol.

Senator HAGEL and I were the prime cosponsors of that resolution.

The adoption of that resolution was perhaps, a dose of reality—laying out, in advance of the completion of the Kyoto negotiations or the anticipated submission of a climate change treaty to the Senate, just what an administration—any administration—would need to win the Senate's advice and consent. Contrary to statements made by some in this administration, the Senate has never voted on the Kyoto Protocol, although the protocol, in its current form, does not meet the requirements of S. Res. 98.

Since that vote in July 1997, international climate change negotiations have covered a wide range of topics in an attempt to craft a balanced treaty. While there have been some important gains and there have been some unfortunate setbacks from the U.S. perspective, I am concerned that, in the Bush administration's zeal to reject Kyoto for its failure to comply with S. Res. 98, the baby is being thrown out with the bath water through a complete abandonment of the negotiating process. Such an abandonment would be very costly to U.S. leadership and credibility and could force the international community to go back to "square one" on certain critical issues such as carbon sequestration and market-based mechanisms—areas which I believe are critical to any future binding climate change treaty.

Still, an examination even of Kyoto's drawbacks can provide the basis for forward movement by the Bush administration.

Let me say that again. An examination, even of Kyoto's drawbacks, can provide the basis for forward movement by the Bush administration.

For example, U.S. negotiators should go back to the negotiating table with proposals that could be achieved internationally. In my opinion, an effective and binding international agreement must include several elements. First, the initial binding emission reduction targets and caps should be economically and environmentally achievable. Such an international agreement should specify increments by which the initial reduction could be racheted downward and made more stringent over time. This architecture could provide a realistic and obtainable target, and it would give U.S. industry more time to prepare to meet such requirements. Additionally, the inclusion of incremental reductions would encourage the development of a range of cleaner, more efficient technologies to meet the long-term goal, namely, the stabilization of greenhouse gas concentrations in the atmosphere. Most important, these steps would give the United States a clearer path toward the goal of dealing seriously with a serious and growing problem.

Recently, we have heard talk by the Bush administration to the effect that the United States should promote voluntary initiatives to meet our international treaty commitments. Well, that sounds good, but it will not work. I note that, in 1993, the former administration undertook an extensive assessment to formulate the U.S. Climate Change Action Plan, which subsequently developed a wide range of voluntary programs and technology strategies to help the United States reduce domestic emissions to 1990 levels. While these remain laudable and important programs, they have not put us on a path toward significantly reducing greenhouse gas emissions. In fact, rather than accomplishing that goal, by the late 1990s, U.S. emissions were at least 11 percent above those 1990 levels. Clearly then, the next global climate change treaty will have to include binding emission limits by industrialized nations, as well as developing nations, specifically the biggest emitters in the developing world. I am talking about China, India, Mexico, Brazil, and others.

Additionally, as I explained at the time we were debating S. Res. 98, the initial commitment by developing countries could be modest, with the agreement specifying a more rigorous approach to growth and emissions over time. Recent press reports indicate that China, the big emitter, exceeding the emissions of the United States very soon, has already made progress in reducing the growth of its greenhouse gas emissions. That is good news. That is encouraging. A future binding climate change agreement could recognise these efforts and provide market-based mechanisms by which China could obtain technological assistance to expand upon its efforts over time.

An international treaty with binding commitments can and should provide for the continued growth of the world's developing nations. The economic growth of Mexico or China, for example, need not be choked off by unrealistically stringent, inflexible emission reduction targets. The initial commitment could be relatively modest, pacing upwards depending upon various factors, with a specific goal to be achieved within a fixed time period. If properly designed, a binding international treaty can accommodate economic growth and environmental improvement in the developing world. This approach provides the means by which China and other key developing nations can grow in a more efficient, environmentally sound manner while also making commitments to reduce their fair share of this global climate change burden.

Using this approach, the Bush administration has a historic opportunity to shape, rather than cripple, the international climate change debate by negotiating an agreement that includes all of the largest emitters of greenhouse gases on a global basis.

It is a huge task no doubt, but it is a huge problem, and it confronts the world, not just he occidental but also the oriental—not just the West but also the East. Such an agreement must also include market mechanisms that are unencumbered by layers of bureaucracy; strong provisions for domestic and international sinks, sequestration, and projects that prevent deforestation; and tough enforcement and compliance requirements.

But any such agreement must also be met by an honest effort on America's domestic front. I am, therefore, very concerned that the President's overall budget does not adequately provide the level of funding necessary to support programs and policies that would address U.S. energy and climate change challenges. So I urge the Bush Administration to include all relevant policy aspects in the energy needs assessment currently under review and to examine the total costs—both economic and environmental—in any national energy strategy. I hope the President will work with Congress on these critical issues to develop a constructive, long-term negotiating path for the future. America leads the world in so many important areas—addressing our global climate change challenges should be front and center.

TRADE POLICY

Mr. BYRD. Mr. President, I have serious concerns about certain trade policy issues that the Bush administration inherited from its predecessor, but which remain unresolved. I refer to the steel crisis, the failure to formulate a coherent trade policy with respect to China, and the failure to recognize that "fast-track" trade negotiating authority represents both an unwarranted diminution of the Constitutional authority of Congress and an invitation to our trade partners to accelerate their attack on the framework of fair trade.

As I have long maintained, U.S. trade policy cannot be complacent as America's manufacturing plants are moved to low-wage countries, a phenomenon that makes it increasingly difficult for American employers to stay competitive and, at the same time, pay good wages and provide good benefits to their workers. While American workers do benefit from lower prices for imported products, too many have been made worse off, on balance, by globalization. As the columnist Michael Kelly recently pointed out, "What the unionists know is that

These issues, whether it is prescription drug benefits under Medicare, Patients' Bill of Rights so doctors make decisions for our health care, an increase in the minimum wage, improvement in education—that will be part of our agenda as we return here next week with the new majority leader, TOM DASCHLE. It is an exciting opportunity.

Having said that, we are still a body of 100 Members where, on a good day, the Democrats can muster a majority of 51 votes. So it is obvious we need bipartisanship; we need cooperation. But I hope this change in the leadership in the Senate will open up our eyes to an array of opportunities that have been missed over the last several years, opportunities to provide better schools, more health care, to give a voice to consumers and families in securing appropriate medical treatment, to give those who are struggling to go to work every day and make a living a chance to succeed in America.

It is a pretty heady agenda; it is pretty challenging; but I think we can rise to that occasion. I look forward to being part of it.

Mr. President, I yield the floor and suggest the absence of a quorum.

The PRESIDING OFFICER. The clerk will call the roll.

The bill clerk proceeded to call the roll.

Mr. BYRD. Mr. President, I ask unanimous consent that the order for the quorum call be rescinded.

The PRESIDING OFFICER (Mr. DURBIN). Without objection, it is so ordered.

Mr. BYRD. Mr. President, I ask unanimous consent that I may speak out of order for not to exceed 30 minutes.

The PRESIDING OFFICER. Without objection, it is so ordered.

Mr. BYRD. I thank the Chair.

REFLECTIONS ON THE SENATE

Mr. BYRD. Mr. President, seeing the current Presiding Officer, the very distinguished senior Senator from Illinois, in the chair reminds me of the days when I first came to this Chamber. At that time, representing the great State of Illinois was the inimitable Everett Dirksen, with his unruly, one might say unkempt—at least in appearance—hair, his florid and flowery oratory, his mellifluous voice, a master at painting word pictures: Everett Dirksen. I can see him standing there. He was the minority leader. And then on this side of the aisle, in the next row behind me and across the aisle, sat the other Senator from the State of Illinois, Paul Douglas: Learned, also a great orator, very impressive—the two Senators from Illinois.

Illinois is continuing in that tradition of Dirksen and Douglas. It sends to the Senate the Senator who presently presides, RICHARD DURBIN, formerly a Member of the House of Representatives, who served there with distinction on the Appropriations Committee, who comes to the Senate Chamber very well equipped, indeed, well equipped by experience, well equipped by heredity, a factor never to be overlooked, a factor which in some ways lays out the destiny of each of us ahead of our years, who also is a very fine speaker, one who does his homework, who likes service to the people.

Then there is Senator FITZGERALD. I believe he is the youngest Senator in today's Chamber, who came to the U.S. Senate, I believe, as a former member of the Senate of the State of Illinois. I hope I am correct. If I am not, I hope the Presiding Officer will indicate by nod that I am in error.

In any event, I express appreciation to the Senator who presently presides for his patience in awaiting my tardy arrival.

I sat in the chair earlier today as the President pro tempore of the Senate, having been elected to that honor by my colleagues, first of all, on this side of the aisle, and then all of my colleagues through a Senate resolution.

Senators are not to speak from the chair. If compliments are to be directed to the Chair or criticism is to be directed to the Chair, the Chair is not supposed to respond. The Chair is only to respond when called upon by way of a parliamentary inquiry or, if necessary, to make a ruling on a point of order. And, of course, it is his or her responsibility to maintain order in the chair. The Chair has the responsibility to maintain, or to restore if necessary, order in the galleries, or in the Senate Chamber, without being called upon by a Senator from the floor. It is the Chair's responsibility to maintain order in the Senate, and the Chair should not await a call by a Senator from the floor for order and decorum; the Chair has that responsibility.

As I sat there earlier today—we, of course, can't call attention to visitors in the galleries. But there are visitors in the galleries. And as I sat in the chair earlier today watching the visitors in the galleries, I reflected. It is a good time to reflect when one is in the chair and nothing is going on on the floor at a given moment and when no Senator is speaking. It is an excellent time for reflection. As I reflected on the silent audience that sits every day in these galleries—I reflected upon the fact that there in those galleries sit the people—our auditors—the people who send us here, the people who pay us our salaries. Silently they sit viewing the Senate, pondering what is said by Senators, watching over our shoulders. They are always there.

Sometimes we may be prone to forget that the people are watching, but they are watching. There in the galleries rests the sovereignty of all that is the Government of this Republic.

CLIMATE CHANGE STRATEGY AND TECHNOLOGY INNOVATION ACT OF 2001

Mr. BYRD. Mr. President, this past weekend I noted an article in the Washington Post that led with these lines:

> Administration officials preparing an alternative to the 1997 global warming agreement that President Bush disavowed in March are focusing on voluntary measures for reducing greenhouse gas emissions—an approach unacceptable to most U.S. allies in Europe and Japan.

Mr. President, last month, I came to this floor to urge the Bush administration not to abandon the progress of the multiyear international negotiations on global climate change. In particular, I urged this administration not to endanger many of the gains that the United States has made in recent years as it has tried to forge a workable, responsible international climate change agreement. So I welcome the subsequent announcement by administration officials that they intend to participate in talks on the Kyoto Protocol scheduled to take place in Bonn, Germany, in July. But an insistence on the part of the United States strictly on voluntary measures would certainly place in jeopardy such gains and would, I believe, undermine the credibility of our Nation at the bargaining table in the future. I cannot agree with a strategy that abandons consideration of binding commitments in favor of voluntary efforts alone.

I stand here as the chief author of Senate Resolution 98 in 1997, the measure that many on both sides of the debate paint as a fatal blow to ratification of the Kyoto Protocol. I beg to differ with that depiction. S. Res. 98, in 1997, was the voice of the Senate, the vox populi, the voice of the people through their elected Representatives, providing guidance to the previous administration—the administration at that time—as its negotiators labored to hammer out a climate change proposal among various international players. That resolution, which passed by a vote of 95-0, simply stated that any international treaty on climate change must include binding commitments by the developing nations, especially the largest emitters, and also that it must not result in serious harm to the U.S. economy.

It also called upon the administration to inform the legislative branch, which under the Constitution of the United States is required to approve the ratification of treaties, as to the estimated costs of commitments by the United States. We want to know what these will cost. And to date, that information has not been forthcoming. That is what we were saying. Tell us what it will cost. Don't sign it; don't sign that protocol until the major emitters among the developing nations of the world have also signed on and have come into the boat with us. They need to sign on with respect to restricting the emissions of greenhouse gases. It must not be the United States alone; it must not be the United States and the developed nations, the industrial nations, alone. We all have a responsibility.

So we said we want the developing nations to get into the same boat with us because they are going to be impacted by the pollution that is emitted into the air, into the atmosphere, because it circles the globe. We are not saying they have to sign up for precisely the same limits we place on ourselves, or to that same degree, but they do need to sign on and get into this boat. Also, we want to know what it is going to cost and what kind of an impact it is going to have on U.S. industries. We don't want our industries to go overseas as a result of an unwise signing of the protocol that would require us to continue to strongly limit ourselves in ways that would encourage manufacturers in this country to go abroad and to establish themselves in the developing countries. Let's all get into the same boat together. There must be a level field insofar as our industries are concerned. Let's don't drive American industries overseas.

It is a little like smoking a cigar in a room. I used to smoke cigars. I smoked for 35 years. I gave up the habit. I said, "I am quitting." The point is that, even though I might have been the only person in the room holding a lighted cigar in my hand, everybody else in the room was inhaling the fragrance of that cigar. And it is the same way with greenhouse gases. They do circle the globe. Everybody breathes the same air, not only the emitters, but also those who are not the emitters.

Had the Senate merely sat on its hands in that instance and allowed an untenable treaty to be submitted for approval, it would have been rejected. That would have been the fatal blow.

The effect of that Senate resolution was not to kill the negotiations—that was not my desire to kill the negotiations—but to help shape them, to strengthen the hand of our negotiators as they tried to reach an agreement that would be acceptable to the American people. No treaty of such magnitude stands any real chance of success in this Nation without the backing of the American people. Our friends in foreign nations surely understand that.

There are also some who do not believe the proliferation of scientific reports that have been produced in recent years concerning climate change. But the body of evidence tells us that something is occurring in our atmosphere at a proportion that is changing our climate and that the human hand has played a role in affecting that change.

"I have lived a long time", as Benjamin Franklin said when he stood before the Constitutional Convention, "and the longer I live, the more convincing proof I see that God still governs in the affairs of men." And so the longer I live, I see that also.

One of the "affairs of men" that I see changing is the atmosphere, the circumstances in which we live every day and every night. As one who has lived more than 83½ years, I have seen some changes taking place out there in the cosmos and around the globe.

I cannot explain those changes. I am not a scientist. But I know that the changes are taking place. The storms are more violent. The storms are more frequent today than they were when I was a lad walking the hills of Wolf Creek in Mercer County, West Virginia. The floods are more frequent. The droughts are more severe, with far more costly results and more often. The forest fires are more frequent, more costly.

The winters have changed. No longer do I experience the snows that I experienced as a boy in southern West Virginia in the mountains and hills. There is still a great deal of snow there, but not like it was 50 years ago, 60 years ago, 70 years ago.

The rains are not as they were. There is something going on out there. The ice masses at the two poles to the north and to the south are diminishing. They are melting. As they melt, conditions change around the globe. The waters of the seas grow higher. There is something going on out there—I know, and I am concerned about it.

We can waste valuable time debating and quibbling over measurements, methodology, findings, and conclusions, or we can accept the simple reality that is right before our eyes—we feel it, we see it, we hear it, we read about it, we appropriate more moneys because of it—the reality that global warming is occurring.

Today, Mr. President, I am introducing the Climate Change Strategy and Technology Innovation Act of 2001. Senator TED STEVENS, the senior Senator from Alaska, a State that is almost halfway across the globe from where we stand today, has agreed to join me in this effort. This legislation calls for a comprehensive strategy underpinned by credible science and economics that will guide U.S. efforts to address the multifaceted problem of global climate change. This legislation also establishes a major research and development effort intended to develop the bold breakthrough technologies that our country will need to address the challenge of climate change.

This legislation is intended to supplement, rather than replace, other complementary proposals to deal with climate change in the near term on both a national and international level. I also note that this bill is technology neutral. This is not a bill to carve out special benefits for coal or oil or gas or, for that matter, for nuclear, renewables, or any other energy resource or technology. This legislation provides the framework for addressing the climate challenge, reaffirms the ultimate goal of stabilizing atmospheric greenhouse gas concentrations, and leaves the technology decisions to energy experts and the marketplace.

An understanding as to why this legislation is necessary must begin with an understanding of the fundamental causes of global climate change. It is virtually indisputable that atmospheric concentrations of carbon dioxide, CO_2, are rising and that mankind is contributing to this rise.

CO_2 has never changed. Like H_2O, it never changes. H_2O, two atoms of hydrogen and one of oxygen constitute water. Water was the same in the beginning when Adam and Eve strolled the paths of that Earthly paradise. Water was H_2O, and carbon dioxide was the same, CO_2. Neither has changed. There are some things that do not change. That is the reason why I say history repeats itself. Human nature does not change. Cain slew Abel in the heat of a sudden rage, and men are still slaying one another.

These rising concentrations drive global climate change, and they are growing as a result of increasing emissions of greenhouse gases. I don't believe I need a scientist to tell me something is going on there. Disturbingly, most greenhouse gases have a very long life span in the atmosphere, ranging from decades to hundreds of years. This means that what is emitted today is added to what was emitted in the 20th century. For example, much of the CO_2, much of the carbon dioxide, emitted during the Second World War is still with us today, and, with each passing year, the concentration is projected to grow to ever-higher levels. So, even if it were possible to stop emitting greenhouse gases today, that would amount to a very small chip in an iceberg of a problem.

It is also important to note that as the concentrations of CO_2 grow, the economic impact of the problem significantly increases. This is an extremely important point, because if we wait until every last bit of uncertainty is resolved, it may well be too late to prevent adverse consequences to the climate system, and it will be very difficult, if not impossible, to take cost-effective action.

Conversely, taking action can be costly. Fossil fuels, such as coal, which emit carbon dioxide are the heart of our economic engine. Thus, as our economy grows, we use more fossil fuels. The President came into West Virginia in the election and advocated spending $2 billion, I believe, on clean coal technology. You are looking at the daddy of clean coal technology. I started that in 1985 with the authorization of $750 million. So I welcome the President's support of clean coal technology.

But there is another side to that coin. I said to the President, I hear they may provide for the costs of additional clean coal technology research by taking it out of fossil fuel research. Please don't do that. That would be robbing Peter to pay Paul.

Yes, that is exactly what happened. The President's budget provides that some of the moneys in fossil fuels research—which means coal, oil, and gas—will be redirected. "Redirected" is the word—that is the key word—redirected to clean coal technology. We are

going to change that, however, and put those moneys back into fossil fuel research. As our economy grows, we use more fossil fuel. Stopping those emissions, even just limiting those emissions, can have the effect of putting the breaks on a purring economy. And that is not just true of the United States, but of other nations as well, particularly in developing nations where economic growth is steep.

In order to solve the problem, we must develop new and cleaner technologies to burn fossil fuels as well as new methods to capture and sequester greenhouse gases, and we must develop renewable technology that is practical and cost-effective. Such an effort will require visionary leadership. Where there is no vision, the people perish. We need, therefore, to muster the strength and the political courage to tackle the climate change challenge in innovative ways.

So the legislation I offer today, cosponsored by my friend, the erstwhile chairman of the Senate Appropriations Committee, the distinguished senior Senator from Alaska, Mr. STEVENS, calls for the creation of a national strategy to define how we can meet these objectives, and it organizes national research efforts and authorizes funding to accomplish these goals.

Moreover, the legislation would establish a regime of responsibility and accountability in the Federal sector for the development of a national climate change response strategy. The strategy includes four key elements that collectively represent a new paradigm to deal with climate change.

The first element defines a range of emission mitigation targets and implementation dates to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level and at a rate that would prevent dangerous interference with the climate system. The strategy would also evaluate how each of the range of targets could achieve reductions in an economically and environmentally sound manner.

The second element calls for substantially increased private- and public-sector investment in bold, innovative energy technologies.

The third element calls for greater research to understand how we may have already altered the climate and how we can adapt to these changes in the future. It would help us understand, for example, how the changing climate may be affecting farming, in Illinois, farming in Florida, farming on the verdant hills of West Virginia—where there might be flooding or drought and how we could best address it.

The fourth element in the paradigm calls for continuing research on the science of climate change to resolve the remaining uncertainties.

To carry out this strategy, this legislation provides for the creation of an administrative structure within the Federal government to accomplish these elements. It creates an office in the White House to coordinate and implement the strategy, and a new office in the Department of Energy that will work on long-term research and development of a type that is not pursued in more conventional research and development programs. The DOE office will focus on breakthrough technological solutions and work in cooperation with existing basic science and applied technology programs to bring an increased focus to the climate change problem. To ensure that these goals are achieved, this bill creates an independent review board that will report to the Congress. Finally, the bill authorizes appropriations for these goals.

This is the greatest nation in the world, the greatest nation the world has ever seen. It is the greatest nation when it comes to putting our talents to the task of advancing revolutionary change. I am confident that the United States possesses the talent, the wisdom, the drive, and the courage to lead a global solution to the climate change challenge that we in Congress and those in the executive branch can rise to meet this challenge. It will task our courage, it will task our energy, it will task our determination, our foresight, and certainly our vision. We not only have the opportunity here, but we also have the responsibility to act now on behalf of those who live today, but even more important, on behalf of those of the unborn who are not even yet knocking at the gates. We hold their future in our hands, and we should understand that. We cannot wait until my children or my grandchildren are standing in these Chambers, standing in the offices of power in Washington or elsewhere. The responsibility is right in our hands now and the future is right in our faces.

I am sure these are matters that will be of some controversy, but we must pause to think of those of our forefathers who responded to the needs of the hour when it was their time to act on behalf of their generation and their children. The responsibility is heavy, but it must be met.

I take this opportunity to thank Senator STEVENS for his support, for his cosponsorship, and for the very great strength which he will add to the effort. It will be a continuing effort. It is going to take a long time. It is a big, big problem, but we can't avoid it because of its bigness. We have to meet it.

Mr. President, I will welcome, as well as Mr. STEVENS, any cosponsors who wish to add their names to this legislation.

I yield the floor.

The PRESIDING OFFICER (Mr. AKAKA). The Senator from Florida, Mr. BILL NELSON, is recognized.

Mr. NELSON of Florida. Mr. President, I have been spellbound by the remarks of the distinguished Senator from West Virginia, addressing a problem facing planet Earth that all too often we have ignored. Yet as he so cogently has expressed, indeed, it is a problem. There is something happening out there.

It has been my concern that the present administration, for whatever reason, has chosen not to approach addressing the issue of global climate change through the Kyoto accords. And because the administration has so decided, it is all the more important for leaders such as Senator BYRD and Senator STEVENS to speak out on a phenomenon that, in fact, is occurring.

The scientific community is fairly unanimous. It is not totally unanimous. Because of that, that is used as an excuse for others to say that global warming is not upon us. That counters all of the scientific evidence and the testimony of a vast majority of the scientific community that it has happened.

We also know that there is, in fact, a correlation, as the distinguished Senator from West Virginia has stated, between the production of CO_2 into the atmosphere and global warming. I commend the Senator from West Virginia for offering this legislation to try to get the Nation's mind focused on the problem and a comprehensive effort of trying to determine what we are going to do about it before it is too late.

In my previous governmental capacity, in the position of Insurance Commissioner of the State of Florida, I tried to sound the alarm bell, and it was very difficult to get people to pay attention, especially insurance companies that would have a great deal to lose because global warming will cause the rise of the seas. When you come from a State such as mine, that has enormous implications since most of our 16 million population is along the coast of Florida. The increase of global temperature will also cause the intensity of storms to increase, as well as their frequency.

Florida is a land that we call paradise, but it happens to be a peninsula sticking down into the middle of something known as Hurricane Highway. Hurricanes are a part of our life, and global warming foretells, for us, an increased intensity of hurricanes and an increased frequency of hurricanes. That has enormous implications on not only our lifestyles but our economic activity—particularly in a State such as Florida that has so many miles exposed to water.

Increased global warming also portends, for the entire globe, the increased likelihood of pestilence and disease, all of which have tremendous impacts on us as a nation if this phenomenon occurs.

The Senator is so kind to stay and listen to my remarks which in large part are directed to him in my affection and appreciation for him and his comments and his legislation. But allow me to divert to the recesses of my memory and to my mind's eye.

In 1986, as I looked out the window of the spacecraft *Columbia*, high above the Earth, in Earth orbit, looking back at home that suddenly, over the course

of days in space, is not Florida or America but home becomes the planet, this beautiful blue and white ball suspended in the middle of nothing—and space is nothing. Space goes on and on. It is an airless vacuum that goes on and on for billions of light-years. There in its midst, suspended, is this wonderful creation called planet Earth, our home. As I would look at the rim of the Earth, I could see what sustains all of our life. I could see the atmosphere. As I would look further, I would start to see how we are messing it up.

For example, in a ground track coming across South America, I could look out the window of the spacecraft to the west and, because of the color contrast, even from that altitude I could see the destruction of the rain forest in the upper Amazon region.

Then, in the same window of the spacecraft, I could look to the east at the mouth of the Amazon River and could see the result of the destruction of the trees for the waters of the Atlantic which were discolored from the silt for hundreds of miles from the mouth of the Amazon. That was a result of the destruction of the trees hundreds of miles upriver.

I came away from that experience becoming more of an environmentalist. I came away from that experience with a profound sense of obligation to become a better steward for our planet Earth.

The legislation that the Senator has offered is another step in attempting to get this Nation and this planet to recognize that something is changing; that we best use the best minds, the best science, and the best technology to address how we can stop what seems to be the inevitable march of warming the temperature of this planet to the point at which it could cause great destruction.

I thank the President for his recognition. I thank the Senator from West Virginia for his statement today and for offering this legislation. I thank him for his very kind indulgence to listen to my remarks, which are complimentary to him for what he was offered here today.

Thank you, Mr. President, I yield the floor.

The PRESIDING OFFICER. The Senator from West Virginia is recognized.

Mr. BYRD. Mr. President, I seek recognition for only a brief statement.

I thank the distinguished Senator from Florida for his observations today. He comes to the Senate as one who is different from the rest of us—different in that his experiences include that of being a former astronaut. My name is BYRD, B-Y-R-D. I don't have the wings of a bird. But I have the imagination that can fly uninhibited through the unlimited bounds of space.

As the Senator from Florida spoke, I found myself traveling with him and looking out of the windows of his spacecraft in wonder at what has happened to planet Earth, the planet that we call home.

I thank him for taking the floor today to tell us about his thoughts and about his experiences in that regard. I think he has opened up a new window of understanding—certainly, to me. I thank him.

I look forward to hearing from Senator NELSON on future occasions and to working with him as we attempt to attack this growing problem. It is one which is going to be costly. It is going to take money. We are severely limited at this time. But I welcome his remarks and always in association with my own.

Mr. President, I send to the desk the bill and ask for its referral.

The PRESIDING OFFICER. The bill will be appropriately referred.

Mr. BYRD. Mr. President, I yield the floor.

Mr. STEVENS. Mr. President, the Climate Change Strategy and Technology Innovation Act of 2001 asks for a commitment of the 107th Congress to Develop bold, innovative technologies to better understand global climate change. I thank my friend Senator BYRD for introducing this Bill and I am proud to be an original co-sponsor.

On May 29, I chaired an Appropriations Committee field hearing in Fairbanks, AK on the impact of global climate change on the arctic environment. Witnesses included Dan Goldin, the Head of the National Aeronautic and Space Administration; Scott Gudes, the acting head of the National Oceanic and Atmospheric Administration; Dr. Rita Colwell, the Director of the National Science Foundation, Charles Groat, the Director of the U.S. Geological Survey; and experts from the International Arctic Research Center and the University of Alaska's Geophysical Institute. Many of the Witnesses noted that recent climate change activity likely stems from a number of factors, including natural variances and human activity.

The degree to which any particular phenomenon or activity is contributing to climate change is not well understood. However, regardless of cause, there has been a dramatic warming trend in the arctic areas of Alaska. Pack ice that usually insulates our coastal villages from winter storms has shrunk by 3 percent a year since the 1970's. Increased storm activity has caused significant beach erosion that may displace entire communities. Sea ice is also thinner than it was 30 years ago. The northwest passage has been ice free for the last three years. Forests appear to moving farther north and west as the permafrost melts. We need better research capabilities to understand global climate change, better planning capabilities to react to climate change impact, and better energy technology infrastructure to keep pace with America's growing energy needs.

Senator BYRD's bill will create a process for the United States to seriously and responsibly address the climate change issue. I look forward to working closely with him to pass this important legislation.

Mr. LIEBERMAN. Mr. President, I rise today to applaud the leadership shown by Senator BYRD and Senator STEVENS with their introduction of the Climate Change Strategy and Technology Innovation Act of 2001. Senator BYRD has shown great courage by taking action to address global warming in such a forthright and courageous manner. As Livy once wrote of the great general Hannibal, Senator BYRD is preferred "in any action which called for vigor and courage, and under his leadership the men"—or in this case his colleagues in the Senate—"invariably showed the best advantage of both dash and confidence." Senator BYRD's vigor and wisdom in introducing this bill are on historic parallel with the acts of Hannibal.

I have been informed that the bill will likely be referred to the Government Affairs Committee, and as chairman of that committee, I look forward to reviewing it in detail. As I understand it, this legislation will create an aggressive comprehensive effort within the executive branch that will provide the scrutiny and creative thought that global warming requires. I hope that it will be the tree off of which other climate change measures will branch. As Senator BYRD has said, it is meant to complement, not replace, other mitigation measures—measures that must include binding targets for emissions reductions.

The timing for the introduction of this bill could not be better. On Wednesday, the National Academy of Sciences released their latest report on climate change at the request of the White House. The White House asked the questions, and the answer was clear: global warming is "real," is caused by human activity, and has potentially disastrous consequences. Now, as President Bush prepares to go to Europe next week, he must heed these disturbing findings and propose meaningful, binding measures to address climate change.

The mandate is clear, we must take action and take action now to stop the overheating of our planet. We must be aggressive and we must be creative. We must harness one of our great American traditions, which is an unparalleled capacity for innovation, and lead the world in doing so. We must use flexible market structures in order to allow that innovation to flourish, we must set the strict caps on emissions that are necessary to drive that innovation.

As I understand their bill, Senators STEVENS and BYRD have laid out a program that will provide the framework for the United States to address the dire problem of climate change. We must accept this challenge and begin to take serious measures to reverse this troubling trend, or future generations will suffer the consequences and remember us with disappointment.

The PRESIDING OFFICER. The Senator from Nevada is recognized.

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Scientists' Report Doesn't Support The Kyoto Treaty

By Richard S. Lindzen

Last week the National Academy of Sciences released a report on climate change, prepared in response to a request from the White House, that was depicted in the press as an implicit endorsement of the Kyoto Protocol. CNN's Michelle Mitchell was typical of the coverage when she declared that the report represented "a unanimous decision that global warming is real, is getting worse, and is due to man. There is no wiggle room."

As one of 11 scientists who prepared the report, I can state that this is simply untrue. For starters, the NAS never asks that all participants agree to all elements of a report, but rather that the report represent the span of views. This the full report did, making clear that there is no consensus, unanimous or otherwise, about long-term climate trends and what causes them.

As usual, far too much public attention was paid to the hastily prepared summary rather than to the body of the report. The summary began with a zinger -- that greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise, etc., before following with the necessary qualifications. For example, the full text noted that 20 years was too short a period for estimating long-term trends, but the summary forgot to mention this.

Our primary conclusion was that despite some knowledge and agreement, the science is by no means settled. We are quite confident (1) that global mean temperature is about 0.5 degrees Celsius higher than it was a century ago; (2) that atmospheric levels of carbon dioxide have risen over the past two centuries; and (3) that carbon dioxide is a greenhouse gas whose increase is likely to warm the earth (one of many, the most important being water vapor and clouds).

But -- and I cannot stress this enough -- we are not in a position to confidently attribute past climate change to carbon dioxide or to forecast what the climate will be in the future. That is to say, contrary to media impressions, agreement with the three basic statements tells us almost nothing relevant to policy discussions.

One reason for this uncertainty is that, as the report states, the climate is always changing; change is the norm. Two centuries ago, much of the Northern Hemisphere was emerging from a little ice age. A millennium ago, during the Middle Ages, the same region was in a warm period. Thirty years ago, we were concerned with global cooling.

Distinguishing the small recent changes in global mean temperature from the natural variability, which is unknown, is not a trivial task. All attempts so far make the assumption that existing computer climate models simulate natural variability, but I doubt that anyone really believes this assumption.

We simply do not know what relation, if any, exists between global climate changes and water vapor, clouds, storms, hurricanes, and other factors, including regional climate changes, which are generally much larger than global changes and not correlated with them. Nor do we know how to predict changes in greenhouse gases. This is because we cannot forecast economic and technological change over the next century, and also because there are many man-made substances whose properties and levels are not well known, but which could be comparable in importance to carbon dioxide.

What we do is know that a doubling of carbon dioxide by itself would produce only a modest temperature increase of one degree Celsius. Larger projected increases depend on "amplification" of the carbon dioxide by more important, but poorly modeled, greenhouse gases, clouds and water vapor.

The press has frequently tied the existence of climate change to a need for Kyoto. The NAS panel did not address this question. My own view, consistent with the panel's work, is that the Kyoto Protocol would not result in a substantial reduction in global warming. Given the difficulties in significantly limiting levels of atmospheric carbon dioxide, a more effective policy might well focus on other greenhouse

substances whose potential for reducing global warming in a short time may be greater.

The panel was finally asked to evaluate the work of the United Nations' Intergovernmental Panel on Climate Change, focusing on the Summary for Policymakers, the only part ever read or quoted. The Summary for Policymakers, which is seen as endorsing Kyoto, is commonly presented as the consensus of thousands of the world's foremost climate scientists. Within the confines of professional courtesy, the NAS panel essentially concluded that the IPCC's Summary for Policymakers does not provide suitable guidance for the U.S. government.

The full IPCC report is an admirable description of research activities in climate science, but it is not specifically directed at policy. The Summary for Policymakers is, but it is also a very different document. It represents a consensus of government representatives (many of whom are also their nations' Kyoto representatives), rather than of scientists. The resulting document has a strong tendency to disguise uncertainty, and conjures up some scary scenarios for which there is no evidence.

Science, in the public arena, is commonly used as a source of authority with which to bludgeon political opponents and propagandize uninformed citizens. This is what has been done with both the reports of the IPCC and the NAS. It is a reprehensible practice that corrodes our ability to make rational decisions. A fairer view of the science will show that there is still a vast amount of uncertainty -- far more than advocates of Kyoto would like to acknowledge -- and that the NAS report has hardly ended the debate. Nor was it meant to.

Mr. Lindzen, a professor of meteorology at MIT, was a member of the National Academy of Sciences panel on climate change.

(See related letter: "Letters to the Editor: Previous Hot Theory Was Global Cooling" -- WSJ June 19, 2001)

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Testimony of Richard S. Lindzen before the Senate Environment and Public Works Committee on 2 May 2001.

I wish to thank Senator Voinovich, Senator Smith and the Environment and Public Works Committee for the opportunity to clarify the nature of consensus and skepticism in the Climate Debate. I have been involved in climate and climate related research for over thirty years during which time I have held professorships at the University of Chicago, Harvard University and MIT. I am a member of the National Academy of Sciences, and the author or coauthor of over 200 papers and books. I have also been a participant in the proceedings of the IPCC (the United Nation's Intergovernmental Panel on Climate Change). The questions I wish to address are the following: What can we agree on and what are the implications of this agreement? What are the critical areas of disagreement? What is the origin of popular perceptions? I hope it will become clear that the designation, 'skeptic,' simply confuses an issue where popular perceptions are based in significant measure on misuse of language as well as misunderstanding of science. Indeed, the identification of some scientists as 'skeptics' permits others to appear 'mainstream' while denying views held by the so-called 'skeptics' even when these views represent the predominant views of the field.

Climate change is a complex issue where simplification tends to lead to confusion, and where understanding requires thought and effort. Judging from treatments of this issue in the press, the public has difficulty dealing with numerical magnitudes and focuses instead on signs (increasing v. decreasing); science places crucial emphasis on both signs and magnitudes. To quote the great 19th Century English scientist, Lord Kelvin, "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind."

As it turns out, much of what informed scientists agree upon is barely quantitative at all:

that global mean temperature has probably increased over the past century,
that CO2 in the atmosphere has increased over the same period,
that the added CO2 is more likely to have caused global mean temperature to increase rather than decrease, and
that man, like the butterfly, has some impact on climate.

Such statements have little relevance to policy, unless quantification shows significance.

The media and advocacy groups have, however, taken this agreement to mean that the same scientists must also agree that global warming "will lead to rising sea waters, droughts and agriculture disasters in the future if unchecked" (CNN). According to Deb Callahan, president of the League of Conservation Voters, "Science clearly shows that we are experiencing devastating impacts because of carbon dioxide pollution." (Carbon dioxide, as a 'pollutant' is rather singular in that it is a natural product of respiration, non-toxic, and essential for life.) The accompanying cartoon suggests implications for severe weather, the ecosystem, and presumably plague, floods and droughts (as well as the profound politicization of the issue). Scientists who do not agree with the catastrophe scenarios are assumed to disagree with the basic statements. This is not only untrue, but absurdly stupid.

Indeed, the whole issue of consensus and skeptics is a bit of a red herring. If, as the news media regularly report, global warming is the increase in temperature caused by man's emissions of CO2 that will give rise to rising sea levels, floods, droughts, weather extremes of all sorts, plagues, species elimination, and so on, then it is safe to say that global warming consists in so many aspects, that widespread agreement on all of them would be suspect ab initio. If it truly existed, it would be evidence of a thoroughly debased field. In truth, neither the full text of the IPCC documents nor even the summaries claim any such agreement. Those who insist that the science is settled should be required to state exactly what science they feel is settled. In all likelihood, it will turn out to be

something trivial and without policy implications except to those who bizarrely subscribe to the so-called precautionary principle a matter I will return to later. (Ian Bowles, former senior science advisor on environmental issues at the NSC, published such a remark on 22 April in the Boston Globe: "the basic link between carbon emissions, accumulation of greenhouse gases in the atmosphere, and the phenomenon of climate change is not seriously disputed in the scientific community." I think it is fair to say that statements concerning matters of such complexity that are not disputed are also likely to be lacking in policy relevant content. However, some policymakers apparently think otherwise in a cultural split that may be worthy of the late C.P. Snow's attention.)

The thought that there might be a central question, whose resolution would settle matters, is, of course, inviting, and there might, in fact, be some basis for optimism. While determining whether temperature has increased or not is not such a question, the determination of climate sensitivity might be. Rather little serious attention has been given to this matter (though I will mention some in the course of this testimony). However, even ignoring this central question, there actually is much that can be learned simply by sticking to matters where there is widespread agreement. For example, there is widespread agreement

that CO2 levels have increased from about 280ppm to 360ppm over the past century, and, that combined with increases in other greenhouse gases, this brings us about half way to the radiative forcing associated with a doubling of CO2 without any evidence of enhanced human misery.

that the increase in global mean temperature over the past century is about 1F which is smaller than the normal interannual variability for smaller regions like North America and Europe, and comparable to the interannual variability for the globe. Which is to say that temperature is always changing, which is why it has proven so difficult to demonstrate human agency.

that doubling CO2 alone will only lead to about a 2F increase in global mean temperature. Predictions of greater warming due to doubling CO2 are based on positive feedbacks from poorly handled water vapor and clouds (the atmosphere's main greenhouse substances) in current computer models. Such positive feedbacks have neither empirical nor theoretical foundations. Their existence, however, suggests a poorly designed earth which responds to perturbations by making things worse.

that the most important energy source for extratropical storms is the temperature difference between the tropics and the poles which is predicted by computer models to decrease with global warming. This also implies reduced temperature variation associated with weather since such variations result from air moving from one latitude to another. Consistent with this, even the IPCC Policymakers Summary notes that no significant trends have been identified in tropical or extratropical storm intensity and frequence. Nor have trends been found in tornados, hail events or thunder days.

that warming is likely to be concentrated in winters and at night. This is an empirical result based on data from the past century. It represents what is on the whole a beneficial pattern.

that temperature increases observed thus far are less than what models have suggested should have occurred even if they were totally due to increasing greenhouse emissions. The invocation of very uncertain (and unmeasured) aerosol effects is frequently used to disguise this. Such an invocation makes it impossible to check models. Rather, one is reduced to the claim that it is possible that models are correct.

that claims that man has contributed any of the observed warming (ie attribution) are based on the assumption that models correctly predict natural variability. Such claims, therefore, do not constitute independent verifications of models. Note that natural variability does not require any external forcing natural or anthropogenic.

that large computer climate models are unable to even simulate major features of past climate such as the 100 thousand year cycles of ice ages that have dominated climate for the past 700 thousand

years, and the very warm climates of the Miocene, Eocene, and Cretaceous. Neither do they do well at accounting for shorter period and less dramatic phenomena like El Ni□os, quasi-biennial oscillations, or intraseasonal oscillations all of which are well documented in the data.

that major past climate changes were either uncorrelated with changes in CO2 or were characterized by temperature changes which preceded changes in CO2 by 100's to thousands of years.

that increases in temperature on the order of 1F are not catastrophic and may be beneficial.

that Kyoto, fully implemented, will have little detectable impact on climate regardless of what one expects for warming. This is partly due to the fact that Kyoto will apply only to developed nations. However, if one expected large global warming, even the extension of Kyoto to developing nations would still leave one with large warming.

None of the above points to catastrophic consequences from increasing CO2. Most point towards, and all are consistent with minimal impacts. Moreover, the last item provides a definitive disconnect between Kyoto and science. Should a catastrophic scenario prove correct, Kyoto will not prevent it. If we view Kyoto as an insurance policy, it is a policy where the premium appears to exceed the potential damages, and where the coverage extends to only a small fraction of the potential damages. Does anyone really want this? I suspect not. Given the rejection of the extensive US concessions at the Hague, it would appear that the Europeans do not want the treaty, but would prefer that the US take the blame for ending the foolishness. As a practical matter, a large part of the response to any climate change, natural or anthropogenic, will be adaptation, and that adaptation is best served by wealth.

Our own research suggests the presence of a major negative feedback involving clouds and water vapor, where models have completely failed to simulate observations (to the point of getting the sign wrong for crucial dependences). If we are right, then models are greatly exaggerating sensitivity to increasing CO2. Even if we are not right (which is always possible in science; for example, IPCC estimates of warming trends for the past twenty years were almost immediately acknowledged to be wrong so too were claims for arctic ice thinning), the failure of models to simulate observations makes it even less likely that models are a reliable tool for predicting climate.

This brings one to what is probably the major point of disagreement:

Can one trust computer climate models to correctly predict the response to increasing CO2?

As the accompanying cartoon suggests, our experience with weather forecasts is not particularly encouraging though it may be argued that the prediction of gross climate changes is not as demanding as predicting the detailed weather. Even here, the situation is nuanced. From the perspective of the precautionary principle, it suffices to believe that the existence of a computer prediction of an adverse situation means that such an outcome is possible rather than correct in order to take 'action.' The burden of proof has shifted to proving that the computer prediction is wrong. Such an approach effectively deprives society of science's capacity to solve problems and answer questions. Unfortunately, the incentive structure in today's scientific enterprise contributes to this impasse. Scientists associate public recognition of the relevance of their subject with support, and relevance has come to be identified with alarming the public. It is only human for scientists to wish for support and recognition, and the broad agreement among scientists that climate change is a serious issue must be viewed from this human perspective. Indeed, public perceptions have significantly influenced the science itself. Meteorologists, oceanographers, hydrologists and others at MIT have all been redesignated climate scientists indicating the degree to which scientists have hitched their futures to this issue.

That said, it has become common to deal with the science by referring to the IPCC 'scientific consensus.' Claiming the agreement of thousands of scientists is certainly easier than trying to

understand the issue or to respond to scientific questions; it also effectively intimidates most citizens. However, the invocation of the IPCC is more a mantra than a proper reflection on that flawed document. The following points should be kept in mind. (Note that almost all reading and coverage of the IPCC is restricted to the highly publicized Summaries for Policymakers which are written by representatives from governments, NGO's and business; the full reports, written by participating scientists, are largely ignored.) In what follows, I will largely restrict myself to the report of Working Group I (on the science). Working Groups II and III dealt with impacts and responses.

The media reports rarely reflect what is actually in the Summary. The media generally replace the IPCC range of 'possible' temperature increases with 'as much as' the maximum despite the highly unlikely nature of the maximum. The range, itself, assumes, unjustifiably, that at least some of the computer models must be correct. However, there is evidence that even the bottom of the range is an overestimate. (A recent study at MIT found that the likelihood of actual change being smaller than the IPCC lower bound was 17 times more likely than that the upper range would even be reached, and even this study assumed natural variability to be what computer models predicted, thus exaggerating the role of anthropogenic forcing.) The media report storminess as a consequence despite the admission in the summary of no such observed relation. To be sure, the summary still claims that such a relation may emerge despite the fact that the underlying physics suggests the opposite. The media's emphasis on increased storminess, rising sea levels, etc. is based not on any science, but rather on the fact that such features have more graphic impact than the rather small increases in temperature. People who have experienced day and night and winter and summer have experienced far greater changes in temperature, and retirement to the sun belt rather than the Northwest Territory represents an overt preference for warmth.

The summary does not reflect the full document (which still has not been released although it was basically completed last August). For example, I worked on Chapter 7, Physical Processes. This chapter dealt with the nature of the basic processes which determine the response of climate, and found numerous problems with model treatments especially with clouds and water vapor. The chapter was summarized with the following sentence: "Understanding of climate processes and their incorporation in climate models have improved, including water vapour, sea-ice dynamics, and ocean heat transport."

The vast majority of participants played no role in preparing the summary, and were not asked for agreement.

The draft of the Policymakers Summary was significantly modified at Shanghai. The IPCC, in response to the fact that the Policymakers Summary was not prepared by participating scientists, claimed that the draft of the Summary was prepared by a (selected) subset of the 14 coordinating lead authors. However, the final version of the summary differed significantly from the draft. For example the draft concluded the following concerning attribution:

From the body of evidence since IPCC (1996), we conclude that there has been a discernible human influence on global climate. Studies are beginning to separate the contributions to observed climate change attributable to individual external influences, both anthropogenic and natural. This work suggests that anthropogenic greenhouse gases are a substantial contributor to the observed warming, especially over the past 30 years. However, the accuracy of these estimates continues to be limited by uncertainties in estimates of internal variability, natural and anthropogenic forcing, and the climate response to external forcing.

The version that emerged from Shanghai concludes instead:

> In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.

In point of fact, there may not have been any significant warming in the last 60 years. Moreover, such warming as may have occurred was associated with jumps that are inconsistent with greenhouse warming.

The preparation of the report, itself, was subject to pressure. There were usually several people working on every few pages. Naturally there were disagreements, but these were usually hammered out in a civilized manner. However, throughout the drafting sessions, IPCC 'coordinators' would go around insisting that criticism of models be toned down, and that 'motherhood' statements be inserted to the effect that models might still be correct despite the cited faults. Refusals were occasionally met with ad hominem attacks. I personally witnessed coauthors forced to assert their 'green' credentials in defense of their statements.

None of the above should be surprising. The IPCC was created to support the negotiations concerning CO2 emission reductions. Although the press frequently refers to the hundreds and even thousands of participants as the world's leading climate scientists, such a claim is misleading on several grounds. First, climate science, itself, has traditionally been a scientific backwater. There is little question that the best science students traditionally went into physics, math and, more recently, computer science. Thus, speaking of "thousands" of the world's leading climate scientists is not especially meaningful. Even within climate science, most of the top researchers (at least in the US) avoid the IPCC because it is extremely time consuming and non-productive. Somewhat ashamedly I must admit to being the only active participant in my department. None of this matters a great deal to the IPCC. As a UN activity, it is far more important to have participants from a hundred countries many of which have almost no active efforts in climate research. For most of these participants, involvement with the IPCC gains them prestige beyond what would normally be available, and these, not surprisingly, are likely to be particularly supportive of the IPCC. Finally, judging from the Citation Index, the leaders of the IPCC process like Sir John Houghton, Dr. Robert Watson, and Prof. Bert Bolin have never been major contributors to basic climate research. They are, however, enthusiasts for the negotiating process without which there would be no IPCC, which is to say that the IPCC represents an interest in its own right. Of course, this hardly distinguishes the IPCC from other organizations.

The question of where do we go from here is an obvious and important one. From my provincial perspective, an important priority should be given to figuring out how to support and encourage science (and basic science underlying climate in particular) while removing incentives to promote alarmism. The benefits of leaving future generations a better understanding of nature would far outweigh the benefits (if any) of ill thought out attempts to regulate nature in the absence of such understanding. With respect to any policy, the advice given in the 1992 report of the NRC, Policy Implications of Greenhouse Warming, remains relevant: carry out only those actions which can be justified independently of any putative anthropogenic global warming. Here, I would urge that even such actions not be identified with climate unless they can be shown to significantly impact the radiative forcing of climate. On neither ground independent justification or climatic relevance is Kyoto appropriate.

SOME COMMENTS ON S.1008:
AMENDMENTS TO THE ENERGY POLICY ACT OF 1992 TO DEVELOP THE UNITED STATES CLIMATE CHANGE RESPONSE STRATEGY

STATEMENT FOR THE RECORD BY
JOHN P. HOLDREN

RECORD FOR THE JULY 18, 2001 HEARING ON S.1008
BEFORE THE COMMITTEE ON GOVERNMENTAL AFFAIRS
UNITED STATES SENATE

Submitted July 25, 2001

My name is John P. Holdren and I am a professor at Harvard in both the Kennedy School of Government and the Department of Earth and Planetary Sciences. Since 1996 I have directed the Kennedy School's Program on Science, Technology, and Public Policy, and for 23 years before that I co-led the interdisciplinary graduate program in Energy and Resources at the University of California, Berkeley. Also germane to the topic of the July 18 hearing, I was a member of President Clinton's Committee of Advisors on Science and Technology (PCAST) and served as chairman of the 1995 PCAST study of "The U.S. Program of Fusion Energy Research and Development", the 1997 PCAST study of "Federal Energy Research and Development for the Challenges of the 21st Century", and the 1999 PCAST study of "Powerful Partnerships: The Federal Role in International Cooperation on Energy Research, Development, Demonstration, and Deployment". A more complete biographical sketch is appended to this statement.

My work at Harvard on energy R&D policy and climate policy over the past five years has been funded, in various combinations, by the U.S. Department of Energy, the Energy Foundation, the Heinz Family Foundation, the MacArthur Foundation, the Packard Foundation, and the Winslow Foundation. The opinions I will offer here are my own and not necessarily those of these funders or of the other organizations with which I am or have been associated. This written statement draws on and supplements testimonies on energy policy that I presented to other Congressional hearings earlier this year and last year (1-3), as well as an article I wrote on energy strategy in the Spring issue of *Issues in Science and Technology* (4) and a review of the PCAST energy studies and their impact that I wrote with a colleague for publication in *Annual Review of Energy and the Environment* this fall (5). I regret that a conflict with my previously scheduled testimony at another Senate hearing (6) prevented my testifying in person at the hearing on S.1008 on July 18. I am grateful for the opportunity to submit this statement for the record.

Overview

I find S.1008 to be a well conceived, well drafted, timely, and important piece of legislation. Many of the thrusts of the bill -- particularly (a) recognition of the key role of technological innovation in energy in ameliorating greenhouse-gas-related risks to the stability of global climate, (b) commitment to a substantial increase in Federal funding of energy R&D, (c) increased focusing of the Federal R&D effort on possibilities for breakthrough technologies, (d) creation of mechanisms for greater coordination of energy-related research and development across agencies and sectors, and (e) commitment to an enhanced degree of international cooperation and coordination with respect to energy-technology innovation that can abate climate-change risks -- parallel some of the main findings and recommendations of the three energy R&D studies I chaired for PCAST in the late 1990s (7-9). I hope that something very much like this bill will be enacted into law.

Climate-Change Risks

The bill's language is correct in saying that continuation of the current trajectory of greenhouse-gas emissions would be inconsistent with the goal of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" -- a goal embodied in international law in a treaty (the 1992 Framework Convention on Climate Change) to which the United States is a full party. The language is also correct in saying that achieving this goal will require transformative changes in the U.S. and world energy systems...changes that can only be achieved in a timely way and at tolerable cost through a substantial acceleration of the pace of energy-technology innovation. These propositions are underpinned by the 2001 climate assessment by the Intergovernmental Panel on Climate Change (10), the U.S. Global Change Research Program report late last year on climate-change impacts on the United States (11), the recent National Academy of Sciences review of key questions in climate science (12), and the PCAST reports mentioned above (7-9), among many others.

While there is as yet no formal or informal agreement on the appropriate target level for stabilization of greenhouse-gas concentrations, I believe that the growing evidence of harmful impacts already being experienced, plus increasingly persuasive simulations of impacts to be expected under higher concentrations, suggest that a target equivalent to a doubling of the pre-industrial concentration of carbon dioxide, or less, will ultimately be agreed. If one assumes for the sake of a simple thought experiment that the net cooling effect of anthropogenic particulate matter in the atmosphere just offsets the warming effects of non-CO2 greenhouse gases and that the target is specified, accordingly, as not exceeding a doubling of the pre-industrial concentration of CO2 itself, then it is easy to show that a "business as usual" trajectory for the 21st century in respect to growth of the world population (reaching 11.1 billion in 2100), growth of per capita economic activity (averaging 1.8% per year in real terms), and reduction in energy intensity of economic activity (declining at 1% per year throughout the century) would require that non-CO2-emitting forms of energy supply would need to grow fifteen-fold between 2000 and 2100 in order to meet the target. If the rate of improvement of energy efficiency (rate of decline of energy intensity) is twice the business as usual figure -- that is, if it averages 2% per year over the whole century -- a three-fold growth in non-CO2-emitting energy supply would still be required during the 21st century (from 100 exajoules of nuclear energy and renewables in 2000 to 300 exajoules of these sources -- plus CO2-sequestering fossil-fuel technologies -- in 2100).

These figures underline the size of the challenge for advanced energy technologies -- those that can increase the rate of improvement of energy efficiency and those that can expand the carbon-free energy supply. This challenge is immense, and far beyond what is likely to achieved at anything like current rates of private and public investment in research, development, demonstration, and deployment of such technologies.

Energy R&D Investments

In FY1997 -- the base year for the 1997 PCAST study of "Federal Energy R&D for the Challenges of the 21st Century" (8) -- Federal budget authority for applied energy-technology R&D (that is, R&D focused specifically on developing or improving technologies for harnessing fossil fuels, nuclear fission, nuclear fusion, renewable energy sources, and increased efficiency of energy end use) totaled about $1.3 billion.[a] Correcting for inflation, this was precisely what the country had been spending for applied energy-

[a] The "energy R&D" line in DOE's budget contains a number of other categories that bring the FY1997 total to almost $2.9 billion. These include Basic Energy Sciences (which includes research in materials science, chemistry, applied mathematics, biosciences, geosciences, and engineering that is not directed at developing any particular class of energy sources), biomedical and environmental research, radioisotope power sources for spacecraft, and some energy management and conservation programs that are not actually R&D at all. The PCAST-97 focus was primarily on the applied energy-technology R&D component, although one recommendation did address, in a general way, the Basic Energy Sciences part of the budget.

technology R&D thirty years earlier, in FY1967, when real GNP was 2.5 times smaller and the reasons for concern about the adequacy of the nation's energy options were far less manifest (8, p 2-8).

Federal applied energy-technology R&D ramped up sharply after the Arab-OPEC oil embargo of 1973-74, reaching a peak of over 6 billion 1997 dollars per year in FY1978 in the process of adding sizable investments in advanced fossil-fuel technologies, renewables, and end-use efficiency to the fission- and fusion-dominated portfolio of the 1960s. After Ronald Reagan assumed the Presidency in 1981, however, with his view that any energy R&D worth doing would be done by the private sector, Federal applied energy-technology R&D spending fell 3-fold in the space of 6 years. A Clean Coal Technology Program that was a joint venture of government and industry brought a brief and modest resurgence from 1988 to 1994, but from then through FY1997 the overall decline continued. Similar declines in government-funded energy R&D were also being experienced in most other industrial nations: the relevant expenditures fell sharply between 1985 and 1995 in all of the other G-7 countries except Japan. Japan's governmental energy R&D budget in 1995 was nearly $5 billion, in an economy only half the size of that of the United States. (Nearly $4 billion of the Japanese total was concentrated in nuclear fission and fusion, however, a pattern similar to that in the United States in the early 1970s.)

Private-sector energy R&D in the United States had been estimated by a 1995 Secretary of Energy Advisory Board study (13) at about $2.5 billion per year at that time. Complete and consistent R&D figures for the private sector are difficult to assemble, but it appears that these expenditures had, like those of the Federal government, been shrinking for some time: the Department of Energy estimated that U.S. industry investments in energy R&D in 1993 were $3.9 billion (1997 dollars), down 33 percent in real terms from 1983's level; a study at Battelle Pacific Northwest Laboratory showed U.S. private-sector energy R&D falling from $4.4 billion (1997 dollars) in 1985 to $2.6 billion in 1994, representing a drop of about 40 percent in this period . Combined public and private investments in applied energy-technology R&D in the mid-1990s, at under $5 billion per year, amounted to less than one percent of the nation's expenditures on fuels and electricity. This meant that the energy business was one of the least research-intensive enterprises in the country measured as the percent of sales expended on R&D. Average industrial R&D expenditures for the whole U.S. economy in 1994 were about 3.5 percent of sales; for software the figure was about 14 percent, for pharmaceuticals about 12 percent, and for semiconductors about 8 percent.

Why had energy R&D investments in the United States fallen so low? On the private-sector side, R&D incentives had been reduced by the rapid fall, since 1981, of the real prices of oil and natural gas (together constituting over 60 percent of U.S. energy supply) and by energy-sector restructuring (resulting in increased pressure on the short-term "bottom line", to the detriment of R&D investments with long time horizons and uncertain returns). Perennial factors limiting energy-industry R&D include the low profit margins that often characterize energy markets, the great difficulty and long time scales associated with developing new energy options and driving down their costs to the point of competitiveness, and the circumstance that much of the incentive for developing new energy technologies lies in externality and public-goods issues (e.g., air pollution, overdependence on oil imports, climate change) not immediately reflected in the balance sheets of energy sellers and buyers.

As for the government side of low propensity to invest in energy R&D, the "let the market do it" philosophy of the Reagan years was certainly important in the steep declines from FY1981 through FY1987. It was augmented by the bad taste left in taxpayers' and policy-makers' mouths by the ill-fated government forays of the late 1970s into very-large-scale energy development and commercialization ventures (notably the Synfuels Corporation and the Clinch River breeder reactor); by the overall Federal budget stringency characterizing the first Clinton term; by Congressional concerns about the effectiveness of DOE

management; and by lack of voter interest, in the absence of gasoline lines or soaring energy bills or rolling blackouts, in energy policy.

The 1997 PCAST study (8) conducted a detailed review of the then-existing portfolio of applied energy-technology R&D in the Department of Energy (where about 95% of Federal energy R&D resides). It concluded that these programs "have been well focused and effective within the limits of available funding" but that they were "not commensurate in scope and scale with the energy challenges and opportunities the twenty-first century will present". It noted that "[t]his judgment takes into account the contributions to energy R&D that can reasonably be expected to be made by the private sector under market conditions similar to today's", and it argued that "the inadequacy of current energy R&D is especially acute in relation to the challenge of responding prudently and cost-effectively to the risk of global climate change from society's greenhouse-gas emissions" (8, p ES-1). It recommended ramping up DOE's applied energy-technology R&D spending from the $1.3 billion level of the FY1997 appropriation (and from the $1.4 billion level of the FY1998 request, not yet acted upon by Congress at the time the report was written) to to $2.1 billion in FY2003 (expressed in constant 1997 dollars). The following table shows the distribution of the proposed increases.

Table 1. PCAST-Recommended DOE Budget Authority for Energy-Technology R&D (millions of constant 1997 dollars)

	FY1997 actual	FY2003 proposed	FY2003 increment over FY1997	share of FY1997-2003 increment	share of FY2003 total
Efficiency	373	755	382	48.6%	36.5%
Fission	42	102	60	7.6%	4.9%
Fossil	365	371	6	0.8%	17.9%
Fusion	232	281	49	6.2%	13.6%
Renewables	270	559	289	36.8%	27.0%
TOTAL	1282	2068	786	100%	100%

The detailed programmatic recommendations within these budget lines stressed the importance of strengthening efforts on what S.1008 has called "breakthrough" technologies -- those with the potential to deliver large improvements in performance. All of the PCAST budget recommendations were unanimous, notwithstanding the diversity of energy (and nonenergy) backgrounds represented on the panel and notwithstanding the history of disagreements among the different energy constituencies about funding priorities. The unanimity on the panel emerged from detailed joint review and discussion of the content of the existing programs, the magnitudes of unaddressed needs and opportunities, the current and likely future role of private industry in each sector, and the size of the public benefits associated with the advances that R&D could bring about. Efficiency and renewables received the great bulk of the increment — and increased their share of the total from 50% in FY1997 to almost 64% in the FY2003 recommendation — because they scored high on potential public benefits and on R&D needs and opportunities unlikely to be fully addressed by the private sector.

Besides these budget recommendations, the panel offered a number of recommendations about overall energy Federal R&D strategy. These included:

- increased coordination between DOE's Basic Energy Sciences (BES) program and its applied-energy-technology programs;[b]

- more systematic efforts within DOE at integrated assessment of its entire energy R&D portfolio "in a way that facilitates comparisons and the development of appropriate portfolio balance, in light of the challenges facing energy R&D and in light of the nature of private sector and international efforts and the interaction of U.S. government R&D with them" (5, p ES-6);

- other improvements in DOE's management of its energy R&D portfolio, including that overall responsibility for that portfolio be assigned to a single person reporting directly to the Secretary of Energy and that increased use be made of industry/national-laboratory/university advisory and peer-review committees, while reducing internal process-oriented reviews.

The panel also recommended strongly that increased attention be devoted to the opportunities for strengthening international cooperation on energy-technology innovation — a recommendation that became the basis for the subsequent PCAST study with this focus (9).

Table 2 shows the distribution, across the energy sectors, of PCAST's recommended budgets for FY1999-2003, Administration requests for FY1999-2002, and Congressional appropriations for FY1999-2001, along with the appropriations from FY1998. These figures show that the requests and appropriations rose, through 2001, in a pattern similar to that recommended by PCAST, but at a slower pace and with a particularly conspicuous shortfall in the renewable category. In addition, since the PCAST study, DOE has undertaken a major effort in integrated analysis of the Department's entire energy R&D portfolio, which reaffirmed the overall direction of the program while highlighting some key gaps, including energy-system reliability and international cooperation on energy-technology innovation. DOE has also made considerable effort at, and progress in, addressing its management challenges.

As indicated in Table 2, the Bush Administration's FY2002 budget request for applied energy-technology R&D, totaling about $1.3 billion, proposed a large step backward — one that would return the country to essentially the FY1997-1998 spending levels. This proposal is not consistent with the Administration's recent statements about the importance it attaches to energy issues and to the role of technological innovation in addressing them. (In fairness, however, it must be said that the FY2002 budget request had to be submitted before Vice President Cheney's energy task force had completed its work). In any case, I hope that Congress's appropriation for FY2002 will not follow the numbers in the Administration's request but will boost energy R&D spending toward the trajectory recommended by PCAST in 1997.

The supplemental appropriations for energy-technology R&D in S.1008 would be a major step in the right direction...and not just for FY2002 but for the ensuring nine years. Specifically, it must be supposed that a substantial fraction of the $4,000,000,000 appropriation for FY2002 to FY2011 -- averaging $400 million per year for the indicated decade -- that the bill would direct to the DOE Office of Carbon Management would be devoted to the responsibilities of that office specified in Subsection 1624.a.2.A, namely to "manage an energy technology research and development program that directly supports the [Climate Change Response] Strategy", with a focus on "high-risk, bold, breakthrough technologies". This

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[b] The PCAST-97 study did not review the content of the BES program, but it did recommend, in light of the close coupling between advances in BES and progress in the applied-energy-technology R&D, that DOE consider expanding its BES effort in parallel with the recommended increase in applied-energy-technology work and the proposed increase in coordination (8, p ES-2).

increment to Federal energy R&D expenditures under existing programs is certainly not excessive in light of the stakes and the opportunities

Table 2. PCAST Recommendations, Administration Requests, and Congressional Appropriations for Applied Energy Technology R&D, FY1998-2003 (millions of as-spent-$)

	effic	renew	foss	fiss	fusn	total
FY98 appropriation	437	272	356	7	223	1295
FY99 appropriation	503	336	384	30	222	1475
Admin request	598	372	383	44	228	1625
PCAST reccmdtn	615	475	379	66	250	1785
FY00 appropriation	552	310	404	40	250	1559
Admin request	615	398	364	41	222	1640
PCAST reccmdtn	690	585	406	86	270	2037
FY01 appropriation	600	375	433	59	255	1722
Admin request	630	410	376	52	247	1715
PCAST reccmdtn	770	620	433	101	290	2214
FY02 Admin request	475	237	333	39	255	1339
PCAST reccmdtn	820	636	437	116	320	2329
FY03 PCAST reccmdtn	880	652	433	119	328	2412

Notes: The values listed here may vary from other tabulations due to rescissions, uncosted obligations, inclusion or exclusion of other budget lines, and other factors. The efficiency line listed here does not include state and local grants, or the Federal Energy Management Program. The nuclear fission line includes only direct civilian energy-related R&D and University training support. The fossil energy line does not include expenditures for the clean coal program, which is a demonstration rather than a research and development effort.

associated with development of a more climate-friendly array of energy technologies than what would be likely to emerge under a business-as-usual R&D pattern, and the conditions the bill attaches to its expenditure seem to me to well designed to maximize desired outcomes.

Beyond Domestic R&D: Aspects of Commercialization and International Cooperation

To the great credit of the drafters, the bill's language calls (at several locations) for measures going beyond the usual boundaries of R&D to move climate-friendly energy-technology innovations forward toward commercial application. This mirrors a finding in the 1997 PCAST study that, when the public benefits of commercial application of the fruits of energy R&D would considerably exceed the expected returns from deployment to private investors (as would be the case for many climate-friendly technologies), a degree of government involvement in pushing beyond R&D toward demonstration and accelerated commercial deployment can be warranted. Both the PCAST report and the language of the bill stress the importance of this being done wherever possible through public-private partnerships, and in all cases with limits on the extent and duration of government support until the "hand-off" to the private sector has been completed.

Also to the credit of the drafters, S.1008 recognizes explicitly that the global climate-change challenge cannot be met through development and deployment of advanced energy technologies in the United States alone, and it draws the logical conclusion that the United States has an interest in cooperating with other countries -- above all the less-developed countries -- to promote the development and implementation of climate-friendly energy technologies everywhere. This, too, mirrors findings of the 1997 PCAST report, as well as of the subsequent 1999 report that was focused entirely on the needs and opportunities for increased U.S. engagement in international cooperation on "energy research, development, demonstration, and deployment". The initiatives that emerged from the 1999 PCAST recommendations in the Clinton Administration's FY2001 budget proposal fared very badly in Congress (of a requested increment of $100 million for international energy cooperation in FY2001, only $8.5 million was appropriated), and it is particularly gratifying now to see the crucial need for increases in such cooperation reflected in this new legislation.

Coordination and Oversight

Two more themes of the PCAST studies that are evident as well in the provisions of S.1008 are the need for better coordination within and among the Federal agencies with responsibilities for energy-technology innovation and for international cooperation with respect to it, and the desirability of making greater use of advice and oversight from experts in the corporate, academic, and NGO sectors. I find most of the provisions of the bill in these directions -- including the coordinating and integrative-analytic functions to be embodied in the White House Office of Climate Change Response, the Interagency Task Force under its direction, the DOE Office of Carbon Management, and its Center for Strategic Climate Change Response, and including the advisory and oversight functions of the U.S. Climate Change Response Strategy Review Board -- to be potentially helpful.

I question, however, whether the bill's provision establishing a procedure for annual certification by National Laboratory directors that the nation's energy R&D efforts are on track technically and financially is really needed or appropriate. This provision appears to be modeled after the process in which the national weapons laboratory directors certify annually the safety and reliability of the U.S. nuclear stockpile. But in that case, the lab directors are certifying matters that are entirely within the province of the three laboratories' collective expertise and responsibility. In the case of energy R&D, the national efforts include much that is done in the national laboratories but also much that is done outside them. The basis on which the laboratories would make the specified certification is therefore much less clear for energy R&D than for the status of the nuclear weapons stockpile. And there is potential for conflict between the energy R&D oversight responsibilities of DOE headquarters -- including the new such responsibilities specified in this bill -- and the certification responsibilities of the national energy labs, as well as potential for disputes arising from the quite different points of view and emphases of the different labs. If, after deliberation and consideration of other points of view, this lab-director certification process does survive in the final legislation, I suggest that the directors of the Livermore National Laboratory, the Los Alamos National Laboratory, and the Princeton Plasma Physics Laboratory should be added to the list of those participating in the certification, because these three labs -- like the others now named -- all have important functions both in applied energy-technology R&D and in basic energy sciences.

Requirements for Analysis

I believe the requirements that this legislation would impose on various offices and agencies for analysis and documentation of their efforts and of the compatibility of these with the overall strategy are, for the most part, reasonable and appropriate. I think, however, that the requirement imposed on the Secretary of State by Subsection 1623.4.C.iii.I, relating to specification of the economic and environmental costs and benefits of proposed international treaties, should be slightly softened by means of the words I have added and underlined in the following revision of the relevant passage:

> "The Secretary of State...shall provide to the Director of the White House Office an opinion that--(I) specifies to the extent possible the economic and environmental costs and benefits of any proposed international treaties or components of treaties that have an influence on greenhouse gas management;"

The reason for this modification is that it is not now possible and probably will never be possible to specify confidently and precisely, in advance, all of the economic and environmental consequences of any policy measure.

References

(1) John P. Holdren. "U.S. Vulnerability to Oil-price Shocks And Supply Constrictions...And How to Reduce It." Committee on Governmental Affairs, United States Senate, Oversight Hearings on Recent Oil-Price Increases. March 24, 2000. http://www.senate.gov/~gov_affairs/032400_holdren.htm.

(2) John P. Holdren. "Improving U.S. Energy Security and Reducing Greenhouse-Gas Emissions: What Role for Nuclear Energy?" Hearing by the Subcommittee on Energy and Environment, Committee on Science, U.S. House of Representatives. July 25, 2000.
http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/energysecurity

(3) John P. Holdren. "Energy Efficiency and Renewable Energy in the U.S. Energy Future", Committee on Science, U.S. House of Representatives, Hearing on The Nation's Energy Future — Roles of Renewable Energy and Energy Efficiency. February 28, 2001.
http://ksgnotes1.harvard.edu/bcsia/library.nsf/pubs/energy-future

(4) John P. Holdren and Samuel F. Baldwin. "The PCAST Energy Studies: Toward a National Consensus on Energy RD^3 Policy." *Annual Review of Energy and the Environment*, 2001, in press.

(5) John P. Holdren. "Searching for a National Energy Strategy." *Issues in Science and Technology*, Vol. XVII, Number 3, 2001, pp 43-50. http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/nat'l-energy

(6) John P. Holdren. "Federal Energy Research and Development for the Challenges of the 21st Century: The 1997 PCAST Study and Its Relevance to Provisions of S.597." Committee on Energy and Natural Resources, United States Senate, Hearing on Legislative Proposals Related to Energy and Scientific Research, Development, Technology Deployment, Education, and Training. July 18, 2001.

(7) President's Committee of Advisors on Science and Technology, Fusion Review Panel. *The U. S. Program of Fusion Energy Research and Development.* Washington, DC: Government Printing Office. July 1995. http://www.ostp.gov/PCAST/fusionenergypub.html.

(8) President's Committee of Advisors on Science and Technology, Energy Research and Development Panel. *Federal Energy Research and Development for the Challenges of the 21st Century.* Washington, DC: Government Printing Office. November 1997. http://www.ostp.gov/Energy/index.html.

(9) President's Committee of Advisors on Science and Technology, Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment. *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation.* Washington, DC: Government Printing Office. June 1999. http://www.ostp.gov/html/p2epage.html.

(10) Intergovernmental Panel on Climate Change. *Third Assessment Report -- Climate Change 2001.* Geneva: IPCC. 2001. http://www.ipcc.ch/

(11) National Assessment Synthesis Team, US Global Change Research Program. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change.* New York: Cambridge University Press. 2000. http://www.gcrio.org/NationalAssessment/

(12) Committee on the Science of Climate Change, National Research Council. *Climate Change Science: An Analysis of Some Key Questions.* Washington, DC: National Academy Press. 2001. http://www.nap.edu/catalog/10139.html

(13) Secretary of Energy Advisory Board, Task Force on Strategic Energy R&D. *Energy R&D: Shaping Our Nation's Future in a Competitive World.* Washington, DC: Government Printing Office. 1995.

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Statement of David G. Hawkins
Director, NRDC Climate Center
Natural Resources Defense Council
For the Record
July 18, 2001

Overview

The Natural Resources Defense Council appreciates the opportunity to submit this statement on the need to develop a long term strategy for stabilizing greenhouse gas concentrations in the atmosphere, as called for by S.1008. The Natural Resources Defense Council (NRDC) is a national, non-profit organization of scientists, lawyers, and environmental specialists, dedicated to protecting public health and the environment. Founded in 1970, NRDC serves more than 500,000 members from offices in New York, Washington, Los Angeles, and San Francisco.

Nearly a decade ago, the U.S. and more than 100 other countries ratified a global climate change treaty that establishes the objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system. This treaty should have spurred adoption of serious policies to combat global warming, including both near-term measure to begin reducing emissions of the pollution that causes global warming and a long-term strategy to achieve the treaty's objective of halting the buildup of these heat-trapping gases in the atmosphere. The United States has done neither. Instead, we have had a decade of delay, during which U.S. greenhouse gas emissions have increased by about 14%. Rather than adopt meaningful policies that would have sent an effective short- and long-term signal to the private sector that constraining carbon emissions was a sound course for business planning, we have relied on voluntary pledge programs that have been effective only in communicating to business leaders that the government is not yet serious about limiting global warming pollution.

NRDC commends Senator Byrd and Senator Stevens for introducing S.1008, which would take a significant positive step by creating a framework for the United States to develop a comprehensive program to combat global warming over the medium and longer term. It would require the government to develop a robust strategy to stabilize concentrations of global warming gases at levels required to protect the planet from unprecedented threats to human and natural systems. As such, we believe that this legislation should be viewed as complementary to immediate steps that can and must be taken to begin curbing emissions of global warming pollution. In our view, it is essential to take immediate steps to begin reducing emissions from power plants, automobiles and buildings, as called for in legislation such as S.556, S.804, S.207, and S.760, while we are simultaneously developing a comprehensive strategy for fulfilling the objective of the Rio climate treaty, as called for by S.1008.

Stabilizing greenhouse gas concentrations

Mr. Chairman, the first rule for getting out of a hole is to stop digging. Every year that we delay adoption of real global warming policies, we dig ourselves deeper and make our ultimate response programs more costly, disruptive, and risky. The United States is better

positioned than any other country in the world to lead the way in showing that economic progress can go hand in hand with controlling global warming pollution. The time for us to exercise that leadership is now.

Global warming is a problem that becomes more difficult to manage the longer we wait to start. Let's review some basic information. Starting about 300 million years ago, for a period spanning about 75 million years, our planet transferred, through geologic processes, vast amounts of carbon from the atmosphere and living organisms to immense underground reserves, producing what we call fossil fuels. Estimates are that some 5 trillion tonnes of carbon were stored in this way. Imagine a 75 million year video documenting the removal of 5 trillion tonnes of material from our global living room and its storage in a remote subterranean repository. Now, imagine running this video in reverse and at hyper speed. That is what we have been doing for the past 150 years.

Since the Industrial Revolution, we have been putting these immense underground carbon stores back into the atmosphere by burning these fuels and we are doing so at ever increasing speed. At current consumption rates, we put back in the air each year about 100,000 years of stored carbon. In the last 150 years we have put about 290 billion tonnes (gigatonnes or Gt) into the air. Amidst the claimed uncertainties about the climate change phenomenon, there is no dispute that these emissions have caused significant increases in atmospheric concentrations of CO2. Today's CO2 levels are about 370 parts per million (ppm), about 30% higher than the pre-industrial level of 280 ppm.

Nor is there any dispute that continued emissions of CO_2 from fossil burning will cause concentrations to go still higher. The latest forecasts for global carbon emissions in the 21st century are sobering. The IPCC's most recent report estimates emissions of between 1000 and 2100 Gt of carbon in the next 100 years—or about 3 to 7 times more than we released in the last 150 years. With cumulative emissions in these ranges, atmospheric CO_2 would build up to between 540 and 970 ppm by the year 2100 and continue to increase unless emissions were cut. Several of the plausible emission scenarios would lead to doubled CO_2 concentrations before a child born today would be eligible for social security.

A final undisputed fact is that once a certain atmospheric concentration is reached, it cannot be significantly reduced for hundreds of years, no matter how drastic a "response program" policymakers decide to put in place. Unfortunately, carbon dioxide's lifetime in the atmosphere is a long one: of each 1000 tons we emit today, 400 of those tons will still be in the air 100 years from now and 150 tons will remain 1000 years from now. So the bed we are making is a procrustean one that we and generations to come must lie on.

As a result of fossil fuel combustion, we already have increased atmospheric CO_2 to levels greater than "at any time during the past 400,000 years," notes the recent National Academy of Sciences report to President Bush. And we are on a path to dramatically higher concentrations in the coming decades. The policy questions this Committee and this Congress must address are whether and when to act to reduce the buildup of CO_2

concentrations in the atmosphere. In NRDC's view the answers are, yes we must act and we should start now.

Yet for more than a decade, fossil-fuel dependent industries have vehemently opposed policies to limit global warming pollution and governments, including the U.S. government, have declined to adopt such policies. One can explain the position of the industrial opponents as driven by the narrow interests of their current business plans but what explains the compliant position of governments, which should show at least some signs of support for the broader public interest. One explanation is the influence of money on politics and enactment of the McCain-Feingold legislation would be a salutary development. A second explanation is that legislators and executive branch officials believe that we can wait until the emergence of greater consensus on the detailed nature of the threats we face from global warming and that acting later will reduce the costs of a response program compared to acting now. NRDC believes this basic assumption—that later is cheaper—is simply wrong.

The basic fact is that further delay in adopting effective policies forecloses options for us and for our children. Further delay will increase the costs of achieving stable atmospheric concentrations at levels less than double or even triple the concentrations under which human societies have evolved. How important is it for us to preserve the option to stabilize greenhouse gas concentrations at these lower levels? The policy dilemma is that we may not know the answers in a manner convincing to all for decades to come. Yet if we delay policy action until we have amassed a more comprehensive and detailed body of evidence of the full range of damages that a changed climate will bring, the planet's growing emissions will have made stabilizing concentrations at levels anywhere near today's levels very much more expensive, if not impossible.

Each year of delay in developing an effective global response program brings us closer to the point of no-return when we lose the ability to limit the increase in greenhouse gas concentrations to lower levels. By failing to act, we are passing these points of no-return without even understanding what we are giving up for ourselves and our descendants. As I mentioned, pre-industrialization levels of CO_2 did not exceed 300 ppm and we are now at 370 ppm, the highest level in 400,000 years. Because the way CO_2 builds up in the atmosphere is well understood, we can determine the cumulative emissions during the next century that allow us to stabilize the atmosphere at various levels, such as 350, 450, 550, 650, or even 750 ppm and experts have done these calculations. The most recent IPCC report summarizes these 21st century emission budgets as follows:

Stabilization target (ppm)	350	450	550	650	750
Cumulative emissions in 21st century (GtC)	280	630	960	1150	1300

The same report forecasts cumulative global emissions during this period, in the absence of effective global warming policies, to range from 1000 to 2100 Gt of carbon. While many members of Congress don't fancy themselves expert in global warming, most have a good understanding of budget fundamentals. In budget terms we are spending at a rate

that far exceeds what we can afford if we learn we need to stabilize CO_2 concentrations in the 350 to 550 ppm range. At first glance, these numbers may suggest we still have lots of time to study this issue but consider that to keep the next hundred years' emissions under 300 Gt we would need to cut today's global emissions *immediately* by more than 60% and keep them there while the world grows in population and affluence. Or we might pursue the cut more gradually but then we must achieve even deeper cuts later to stay within the same budget. While this example is for the 350 ppm option, the same dynamic exists for each of the higher stabilization targets: the longer we delay adoption of policies that limit business as usual growth in emissions, the deeper the cuts the planet must achieve to hit any stabilization target. And if we delay too long, each successive stabilization target becomes impossible to achieve.

Dr. James E. Edmonds of the Department of Energy's Pacific Northwest National Laboratory and colleagues have estimated least-abatement cost schedules for reducing emissions to meet these stabilization targets. He points out that these schedules require global emissions to drop below business as usual paths in the very near future. Here is a summary of this information as he presented it to the Senate Energy Committee on June 28, 2001:

CO_2 Concentration (ppmv)	350	450	550	650	750
Maximum Global CO_2 Emissions (billions of tonnes carbon per year)	8.5	9.5	11.2	12.9	14.0
Year in which Global Emissions Must Break from Present Trends	Today	2007	2013	2018	2023

As can be seen, for the lower targets, the dates for achieving significant global emission reductions are upon us now and the dates for preserving even the higher targets are very close. To appreciate that these dates do not allow time for further delay in adopting policies, consider the sequence of events that must occur to actually succeed in reducing global emissions. Clear public policies must be debated and adopted, not just in the U.S. but in other countries too. The private sector must develop strategies for response to those policies. The strategies must be translated into specific investment decisions needed to carry out the strategies, most likely involving additional development work for certain technologies. The investment decisions must be followed with detailed engineering and planning work. And this work must be followed by deployment of lower-carbon technologies in the field on a sufficient scale to actually reduce global emissions below current forecasted increases. Thus, to reduce global emissions by dates like 2007-2020, we must start today with adoption of effective policies.

Stated another way, further delay in adopting policies to limit global warming pollution means we are discarding the options of stabilizing concentrations at levels closer to the lower end of the range of targets. I cannot prove today that stabilizing CO_2 at 350 ppm is essential for our well-being. But I think it is self-evident that it is not responsible to eliminate this option without any assurance that we can live well with the resulting future. As the National Academy of Sciences panel noted in its report to President Bush, "risk increases with increases in both the rate and the magnitude of climate change." By committing ourselves to ever-higher CO_2 concentrations, we are committing to higher rates and magnitudes of climate change for our descendants and ourselves.

Fortunately, there are no technical or economic impediments to adopting policies today that will restore U.S. leadership on fighting global warming and send important signals to the private sector and to other countries that the time for effective action has arrived. Congress has before it a number of major legislative initiatives that will address the principal sources of global warming pollution in the U.S. in a way that will stimulate the new technology that is essential to meeting the challenges of limiting these emissions during the remainder of this century.

Near-term domestic policies to address global warming

A. Comprehensive power plant clean-up legislation

NRDC supports comprehensive legislation to reduce all four major pollutants from electric generation—sulfur oxides, nitrogen oxides, mercury and carbon dioxide. Electric generation is responsible for 40% of total U.S. CO_2 emissions. We have the technology to make significant reductions in CO_2 from this sector though a combination of efficiency measures on the supply and the demand side, and through increased reliance on cleaner fuels. Enactment of a cap and trade program for CO_2 from the electric sector would produce the needed market signal to all the players in the electric production and consumption sectors that there is value in reducing carbon emissions. The bipartisan bill, S. 556, the "Clean Power Act," sponsored by Senators Kerry, Lieberman, Collins, Jeffords and Snowe would accomplish this objective and NRDC strongly supports it.

Complementary policies to reduce emissions from electric generation include renewable portfolio standards proposed in the last Congress in S. 1369, to facilitate the deployment of renewable energy resources, a public benefits fund as proposed in last year's S. 1369 and this year's S. 597, to promote continued investments in demand side management programs and net metering provisions (as found in both bills), to promote clean and efficient distributed generation.

B. Policies to Reduce Petroleum Dependence and Protect the Environment and Public Health

1. Close the Light Truck Loophole and Raise Fuel Economy Standards to 40 Miles per Gallon

Incentives for advanced technology vehicles will be most effective if enacted in combination with updated fuel economy standards. This can be accomplished in two steps. First, congress should quickly eliminate the light truck loophole in the current fuel economy standards. The share of new vehicles that are classified as light trucks (SUVs, minivans, and pickups) has increased dramatically from 20 percent of sales when the CAFE law was first enacted in 1975 to nearly 50 percent of the market today. Yet the vast majority of vehicles currently regulated as light trucks are in fact used in exactly the same way as passenger cars. EPA recognized the need to eliminate the light truck loophole in its Tier II tailpipe standards beginning in 2004. Congress should follow this lead and eliminate the light truck loophole in fuel economy regulations in the same time frame. Congress should raise the overall fuel economy standard for the entire light vehicle fleet over a longer time period. A recent report by the Union of Concerned Scientists shows that the fleet average efficiency could be increased to 40 miles per gallon (mpg) by 2012 and 55 miles per gallon by 2020. The 40 mpg standard could be achieved through

incremental improvements to vehicles with conventional drive trains, although hybrid and fuel cell vehicles would likely contribute to achieving this efficiency level. The 55 mpg standard could be most easily achieved by applying hybrid technology throughout the vehicle fleet.[1]

Congress should also set standards for replacement tires. It is a little known fact that auto manufacturers use highly-efficient tires to comply with current CAFE requirements, but comparable tires are not available to the consumers as replacements. Congress should require replacement tires to meet the same specifications as those sold on new cars. This measure alone would save over 70% more oil than is likely to be found if drilling were permitted in the Arctic National Wildlife Refuge.

2. Pass the CLEAR Act: Tax Incentives for Advanced Technology Vehicles and Alternative Fuels

The CLEAR Act (S. 760) provides a comprehensive set of performance-based tax incentives to accelerate the commercialization of advanced technology vehicles and alternative fuels. This bill is a major advance over previous vehicle tax credit proposals because it is the first proposal to link publicly-funded incentives directly to the public benefits provided by the vehicles that get the incentive, in this case the amount of petroleum and carbon dioxide displaced. This is accomplished by linking the amount of the tax credit it offers in part to the actual fuel economy of the qualifying vehicles. The bill also includes important provisions to ensure that public support only goes to truly advanced vehicles that reduce local air pollution as well as global warming pollution and petroleum consumption.

The policy advances incorporated into CLEAR reflect the collective advice of a unique coalition of environmental advocates and automakers. Public interest organizations that have joined NRDC in endorsing the CLEAR Act include the Union of Concerned Scientists, Environmental Defense, the American Council for an Energy-Efficient Economy, the Ecology Center of Ann Arbor, Michigan and the Michigan Environmental Council.

3. Establish Incentives to Promote Smart Growth Development Patterns

Gasoline use also can be reduced by directing real estate development away from urban sprawl and toward "smart growth." Smart-growth suburbs reduce the need to drive by 30 percent or more, cutting household expenditures on transportation.[2] An important incentive for smart growth is to establish mortgage qualification rules that recognize the

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[1] Union of Concerned Scientists, *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles* .(June 2001). Available from http://www.ucsusa.org/

[2] David Goldstein, "Mortgages Can Remove the Incentive for Sprawl," *Earthword: The Journal of Environmental and Social Responsibility*, Issue #4.

increased affordability of homes that have low transportation costs because they are located in areas with good access to public transportation.

4. Modify the Ethanol Tax Credit to Make it Performance-Based

The largest incentive currently going to alternative fuels is the excise tax credit provided for ethanol. Unfortunately, the environmental benefits generated by this tax credit are limited because it does not currently incorporate performance criteria. Most ethanol is currently produced from corn and requires high levels of chemical and fossil fuel inputs that are almost as great as those for conventional gasoline over the full fuel cycle of production and use. The existing tax incentive for ethanol could be made much more effective by linking the amount of the credit to the net reduction in global warming pollution or fossil fuel consumption achieved by the ethanol producer. This would encourage ethanol producers to shift to less energy intensive feedstocks, such as agricultural wastes and perennial crops, and to improve the efficiency of their conversion processes.

C. Benefits of a Comprehensive Policies to Promote Advanced Technology Vehicles and Alternative Fuels

The economic and environmental benefits of enacting the comprehensive set of policies described here would be profound. EPA estimates that the average light truck on the road today produces 164 pounds of smog-forming pollution (hydrocarbons plus nitrogen oxides) and 8.0 tons of global warming pollution in traveling 14,000 miles each year. This does not include upstream emissions associated with producing the fuel, which would add about 11 pounds of smog-forming pollution and 2 tons of global warming pollution, bring the totals to 175 pounds of smog-forming pollution and 10 tons of global warming pollution. Conventional new vehicles are substantially cleaner than this average with respect to smog-forming pollution, but have roughly the same fuel economy and therefore the same global warming pollution emissions as the vehicle existing vehicle it is likely to replace. For example, a vehicle meeting the National Low Emission Vehicle standard would emit only 12 pounds of smog-forming pollution from its tailpipe, but upstream emissions would still add 11 pounds, bringing its total impact to 23 pounds of smog-forming pollution and 10 tons of global warming pollution. In contrast, a hybrid vehicle qualifying for a $3000 tax credit under the CLEAR Act would emit less than 1 pound of smog-forming pollution from its tailpipe and would use only half as much fuel. As a result, its total impact would be only 6 pounds of smog-forming pollution and 5 tons of global warming pollution.

Aggregating from the vehicle level to the fleet level, the Union of Concerned Scientist (UCS) estimates that the combination of tax incentives and higher fuel economy standards advocated here would save 540 million barrels of oil in the year 2010, reduce upstream smog-forming pollution by 320 million pounds, and reduce global warming pollution by 273 million tons. By 2020 the savings would be even more dramatic: 1.8

billion barrels of oil, 1000 pounds of smog-forming pollution, and 890 million tons of global warming pollution. All of these benefits would be achieved while saving consumers billions of dollars: nearly $10 billion in 2010 and $28 billion in 2020 according to UCS.

D. Legislation to Provide Energy-Efficiency Incentives for the Buildings Sector

"The Energy-efficient Buildings Incentives Act" (S. 207), introduced by Sens. Robert Smith (R-N.H.) and Diane Feinstein (D-Calif.), would provide tax incentives for energy efficiency in buildings. Buildings are an often-overlooked source of energy waste. They consume over a third of U.S. energy use and account for about a third of total air pollution in the United States. S.207 would provide incentives for the construction of energy-efficient commercial buildings, schools, rental housing and new homes, cutting their energy needs by 30 percent to 50 percent. It also would provide tax incentives for the purchase of energy-efficient air conditioners, heating and cooling systems, and solar water heating and photovoltaic systems.

Energy use in buildings can be cut in half or better using cost-effective technologies that are available to those consumers that are willing to search them out. But in practice most of those technologies simply are not options for energy users, whether consumers or businesses, because they are too hard to find. Economic incentives can cause the entire chain of production and consumption, from the manufacturer to the contractor or vendor to the consumer, to accept new technologies rapidly. In the few cases where utility programs have been consistent enough across the country and long-lasting enough, new products have been introduced that have become or will become the most common product in the marketplace, with reductions in energy use of 30%-60%.

Examples include:

- Refrigerators, where, new products that are available this year consume less than a quarter of the energy of their smaller and less feature-laden counterparts 30 years ago. The last step forward, saving 30%, resulted from a coordinated incentive program, the Super Efficient Refrigerator Program (SERP), which was sponsored by utilities with the advice of the U.S. Environmental Protection Agency.

- Clothes washers, where some 10% of the market now provides cleaner clothes at a reduction in energy use of 60% or more. This gain in efficiency resulted from a program organized by the Consortium for Energy Efficiency (CEE) and supported by Energy Star. New standards adopted by the Department of Energy – and supported by the manufacturers – will bring all of the market to this level by 2007.

- Fluorescent lighting systems, where new technologies that also will be required by manufacturer-supported federal standards will reduce lighting energy

consumption by 30% compared to mid-70's practice while improving the performance of the lighting system.

The policies embodied in S. 207 are built on success stories like these.

Manufacturers have pointed out that in order to introduce new technologies that cost more and that are perceived to be risky, they need the assurance that the same product can be sold throughout the country and that the financial incentives will be available for enough time to make it worth investing in production. S. 207 does this by providing nationally uniform performance targets for buildings and equipment that will be eligible for tax incentives for 6 full years.

It's worth mentioning that S. 207 and other policies improving efficiency of electricity and natural gas use have immediate benefits for consumers and the economy. Let's start with the problem of electric reliability. Not only in California and the West, but in other parts of the country, we are facing the risk of electrical blackouts and/or excessively high electricity prices this summer and next. Regions that are confronting these problems are trying to move forward aggressively both on energy efficiency programs and on power plant construction. But the lead times for most actions on the supply side are far too long to provide a solution. And demand-side approaches attempted on a state-by-state level are much less effective than coordinated national activities.

Here, S. 207 could be a critical piece of a national solution. Air conditioners, for example, represent about 30% of summertime peak electric loads. Air conditioners that use a third less power can be purchased today, but they are not produced in large enough quantities to make a difference to peak load. If incentives are made available, manufacturers could begin to mass-produce these products in a matter of months, not years. Mass production and increased competition for tax incentives will drive prices sharply lower, so the incentives will be self-sustaining in the long-term. And with 5 million air conditioners being sold every year, a sudden increase in energy efficiency could have a significant effect in balancing electricity supply and demand even after less than a year.

Another peak power efficiency measure with a very short lead time is installing energy-efficient lighting systems – either new or retrofit – in commercial buildings. Some 15% of electrical peak power results from lighting in commercial buildings. Efficient installations, such as those NRDC designed and installed in our own four offices, can cut peak power demand by over two-thirds while improving lighting quality. Lighting systems are designed and installed with a lead time of months, so incentives for efficient lightings as provided in S. 207 could begin to mitigate electric reliability problems as soon as next summer.

The second major new problem is the skyrocketing cost of natural gas, which caused heating bills throughout the country to increase last winter. Improved energy efficiency can cut gas use for the major uses – heating and water heating – by 30%-50%. Much of this potential could be achieved in the short term, because water heaters need replacement

about every ten years, and are the second largest user of natural gas in a typical household (and largest gas user in households living in efficient homes or in warm areas).

These types of quick-acting incentives help consumers in two different ways: first, they provide new choices that are not now available in practice for families and businesses that want to cut their own energy costs while obtaining tax relief. But they also help the non-participants, because reduced demand cuts prices for everyone.

E. Benefits of Integrated Policies to Promote Efficiency, Renewable Energy and Limit Carbon Emissions

The beneficial impacts of policies like those described above are magnified when assembled into an integrated program that combines incentives for energy efficiency and renewable energy and explicit measures to limit carbon emissions. An example of such an integrated program can be found in the November 2000, Department of Energy Report, "Scenarios for a Clean Energy Future." The policies described in the Clean Energy Future report include greatly expanded research and development funding for energy efficiency and renewable energy breakthroughs, a renewable energy portfolio standard, incentives for renewable energy production and suites of performance standards and incentives for the vehicles, buildings, and industrial sectors. DOE's report forecasts that together, these policies would avoid the need for construction of over 60 percent of the nation's base-case predicted need for new electric power plants over the next 20 years. The policies also would lower Americans' electric bills by over $120 billion per year, cut CO_2 pollution by one-third, and slash emissions of other pollutants in half. These policies are not the imaginings of wild-eyed dreamers. In many cases they amount to expanding programs that have proven to work well already: cap and trade emissions programs; tax incentives; appliance standards; targeted research and development programs; and well-structured voluntary performance commitment programs. Adoption of such programs now is feasible and we urge members of the Committee to lend their support to early enactment of each of these measures.

II

107TH CONGRESS
1ST SESSION

S. 1008

To amend the Energy Policy Act of 1992 to develop the United States Climate Change Response Strategy with the goal of stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, while minimizing adverse short-term and long-term economic and social impacts, aligning the Strategy with United States energy policy, and promoting a sound national environmental policy, to establish a research and development program that focuses on bold technological breakthroughs that make significant progress toward the goal of stabilization of greenhouse gas concentrations, to establish the National Office of Climate Change Response within the Executive Office of the President, and for other purposes.

IN THE SENATE OF THE UNITED STATES

JUNE 8, 2001

Mr. BYRD (for himself and Mr. STEVENS) introduced the following bill; which was read twice and referred to the Committee on Governmental Affairs

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A BILL

To amend the Energy Policy Act of 1992 to develop the United States Climate Change Response Strategy with the goal of stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, while minimizing adverse short-term and long-term economic and social impacts, aligning the Strategy with United States energy policy, and promoting a sound national environmental policy, to establish a research and

development program that focuses on bold technological breakthroughs that make significant progress toward the goal of stabilization of greenhouse gas concentrations, to establish the National Office of Climate Change Response within the Executive Office of the President, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Climate Change Strategy and Technology Innovation Act of 2001".

SEC. 2. FINDINGS.

Congress finds that—

(1) evidence continues to build that increases in atmospheric concentrations of greenhouse gases are contributing to global climate change;

(2) in 1992, the Senate ratified the United Nations Framework Convention on Climate Change, done at New York on May 9, 1992, the ultimate objective of which is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system";

(3) although science currently cannot determine precisely what atmospheric concentrations are "dangerous", the current trajectory of greenhouse gas

emissions will lead to a continued rise in greenhouse gas concentrations in the atmosphere, not stabilization;

(4) the remaining scientific uncertainties call for temperance of human actions, but not inaction;

(5) greenhouse gases are associated with a wide range of human activities, including energy production, transportation, agriculture, forestry, manufacturing, buildings, and other activities;

(6) the economic consequences of poorly designed climate change response strategies, or of inaction, may cost the global economy trillions of dollars;

(7) a large share of this economic burden would be borne by the United States;

(8) stabilization of greenhouse gas concentrations in the atmosphere will require transformational change in the global energy system and other emitting sectors at an almost unimaginable level—a veritable industrial revolution is required;

(9) such a revolution can occur only if the revolution is preceded by research and development that leads to bold technological breakthroughs;

(10) over the decade preceding the date of enactment of this Act—

(A) energy research and development budgets in the public and private sectors have declined precipitously and have not been focused on the climate change response challenge; and

(B) the investments that have been made have not been guided by a comprehensive strategy;

(11) the negative trends in research and development funding described in paragraph (10) must be reversed with a focus on not only traditional energy research and development, but also bolder, breakthrough research;

(12) much more progress could be made on the issue of climate change if the United States were to adopt a new approach for addressing climate change that included, as an ultimate long-term goal—

(A) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system; and

(B) a response strategy with 4 key elements consisting of—

(i) definition of interim emission mitigation targets coupled with specific mitiga-

tion approaches that cumulatively yield stabilized atmospheric greenhouse gas concentrations;

(ii) a national commitment—

(I) to double energy research and development by the United States public and private sectors; and

(II) in carrying out such research and development, to provide a high degree of emphasis on bold, breakthrough technologies that will make possible a profound transformation of the energy, transportation, industrial, agricultural, and building sectors of the United States;

(iii) climate adaptation research that focuses on response actions necessary to adapt to climate change that may have occurred or may occur under any future climate change scenario; and

(iv) continued research, building on the substantial scientific understanding of climate change that exists as of the date of enactment of this Act, that focuses on resolving the remaining scientific, technical,

and economic uncertainties, to aid in the development of sound response strategies; and

(13) inherent in each of the 4 key elements of the response strategy is consideration of the international nature of the challenge, which will require—

(A) establishment of joint climate response strategies and joint research programs;

(B) assistance to developing countries and countries in transition for building technical and institutional capacities and incentives for addressing the challenge; and

(C) promotion of public awareness of the issue.

SEC. 3. PURPOSE.

The purpose of this Act is to implement the new approach described in section 2(12) by developing a national focal point for climate change response through—

(1) the establishment of the National Office of Climate Change Response within the Executive Office of the President (referred to in this section as the "White House Office") to develop the United States Climate Change Response Strategy (referred to in this section as the "Strategy") that—

(A) incorporates the 4 key elements of that new approach;

(B) is supportive of and integrated in the overall energy, transportation, industrial, agricultural, forestry, and environmental policies of the United States;

(C) takes into account—

(i) the diversity of energy sources and technologies;

(ii) supply-side and demand-side solutions; and

(iii) national infrastructure, energy distribution, and transportation systems;

(D) provides for the inclusion and equitable participation of Federal, State, tribal, and local government agencies, nongovernmental organizations, academia, scientific bodies, industry, the public, and other interested parties;

(E) incorporates new models of Federal-State cooperation;

(F) defines a comprehensive energy technology research and development program that—

(i) recognizes the important contributions that research and development pro-

grams in existence on the date of enactment of this Act make toward addressing the climate change response challenge; and

(ii) includes an additional research and development agenda that focuses on the bold, breakthrough technologies that are critical to the long-term stabilization of greenhouse gas concentrations in the atmosphere;

(G) includes consideration of other efforts to address critical environmental and health concerns, including clean air, clean water, and responsible land use policies; and

(H) incorporates initiatives to promote the deployment of clean energy technologies developed in the United States and abroad;

(2) the establishment of the Interagency Task Force, chaired by the Director of the White House Office, to serve as the primary mechanism through which the heads of Federal agencies work together to develop and implement the Strategy;

(3) the establishment of the Office of Carbon Management and the Center for Strategic Climate Change Response within the Department of Energy—

(A) to manage, as their primary responsibility, an innovative research and development program that focuses on the bold, breakthrough technologies that are critical to the long-term stabilization of greenhouse gas concentrations in the atmosphere; and

(B) to provide analytical support and data to the White House Office, other agencies, and the public;

(4) the establishment of an independent review board—

(A) to review the Strategy and annually assess United States and international progress toward the goal of stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system; and

(B) to assess—

(i) the performance of each Federal agency that has responsibilities under the Strategy; and

(ii) the adequacy of the budget of each such Federal agency to fulfill the responsibilities of the Federal agency under the Strategy; and

(5) the establishment of offices in, or the carrying out of activities by, the Department of Agriculture, the Department of Transportation, the Environmental Protection Agency, and other Federal agencies as necessary to carry out the amendment made by section 4.

SEC. 4. UNITED STATES CLIMATE CHANGE STRATEGY AND TECHNOLOGY INNOVATION.

Title XVI of the Energy Policy Act of 1992 (42 U.S.C. 13381 et seq.) is amended—

(1) by inserting after the title heading the following:

"Subtitle A—General Provisions";

and

(2) by adding at the end the following:

"Subtitle B—United States Climate Change Strategy and Technology Innovation

"SEC. 1621. DEFINITIONS.

"In this subtitle:

"(1) CENTER.—The term 'Center' means the Center for Strategic Climate Change Response established by section 1624(c).

"(2) CLIMATE-FRIENDLY TECHNOLOGY.—The term 'climate-friendly technology' means any energy

supply or end-use technology that, over the life of the technology and compared to similar technology in commercial use as of the date of enactment of this subtitle—

"(A) results in reduced emissions of greenhouse gases;

"(B) may substantially lower emissions of other pollutants; and

"(C) may generate substantially smaller or less hazardous quantities of solid or liquid waste.

"(3) DEPARTMENT.—The term 'Department' means the Department of Energy.

"(4) DEPARTMENT OFFICE.—The term 'Department Office' means the Office of Carbon Management of the Department established by section 1624(a).

"(5) FEDERAL AGENCY.—The term 'Federal agency' has the meaning given the term 'agency' in section 551 of title 5, United States Code.

"(6) GREENHOUSE GAS.—The term 'greenhouse gas' means an anthropogenic gaseous constituent of the atmosphere that absorbs and re-emits infrared radiation.

"(7) INTERAGENCY TASK FORCE.—The term 'Interagency Task Force' means the United States Climate Change Response Interagency Task Force established under section 1623(d).

"(8) KEY ELEMENT.—The term 'key element', with respect to the Strategy, means—

"(A) definition of interim emission mitigation targets coupled with specific mitigation approaches that cumulatively result in stabilization of greenhouse gas concentrations;

"(B) a national commitment—

"(i) to double energy research and development by the United States public and private sectors; and

"(ii) in carrying out such research and development, to provide a high degree of emphasis on bold, breakthrough technologies that will make possible a profound transformation of the energy, transportation, industrial, agricultural, and building sectors of the United States;

"(C) climate adaptation research that focuses on response actions necessary to adapt to climate change that may have occurred or may

occur under any future climate change scenario; and

"(D) research that focuses on resolving the remaining scientific, technical, and economic uncertainties associated with climate change to the extent that those uncertainties bear on strategies to achieve the long-term goal of stabilization of greenhouse gas concentrations.

"(9) QUALIFIED INDIVIDUAL.—

"(A) IN GENERAL.—The term 'qualified individual' means an individual who has demonstrated expertise and leadership skills to draw on other experts in diverse fields of knowledge that are relevant to addressing the climate change response challenge.

"(B) FIELDS OF KNOWLEDGE.—The fields of knowledge referred to in subparagraph (A) are—

"(i) the science of primary and secondary climate change impacts;

"(ii) energy and environmental economics;

"(iii) technology transfer and diffusion;

"(iv) the social dimensions of climate change;

"(v) climate change adaptation strategies;

"(vi) fossil, nuclear, and renewable energy technology;

"(vii) energy efficiency and energy conservation;

"(viii) energy systems integration;

"(ix) engineered and terrestrial carbon sequestration;

"(x) transportation, industrial, and building sector concerns;

"(xi) regulatory and market-based mechanisms for addressing climate change;

"(xii) risk and decision analysis;

"(xiii) strategic planning; and

"(xiv) the international implications of climate change response strategies.

"(10) REVIEW BOARD.—The term 'Review Board' means the United States Climate Change Response Strategy Review Board established by section 1626.

"(11) SECRETARY.—The term 'Secretary' means the Secretary of Energy.

"(12) STABILIZATION OF GREENHOUSE GAS CONCENTRATIONS.—The term 'stabilization of greenhouse gas concentrations' means the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, as contemplated by the United Nations Framework Convention on Climate Change, done at New York on May 9, 1992.

"(13) STRATEGY.—The term 'Strategy' means the United States Climate Change Response Strategy developed under section 1622.

"(14) WHITE HOUSE OFFICE.—The term 'White House Office' means the National Office of Climate Change Response of the Executive Office of the President established by section 1623(a).

"SEC. 1622. UNITED STATES CLIMATE CHANGE RESPONSE STRATEGY.

"(a) IN GENERAL.—The Director of the White House Office shall develop the United States Climate Change Response Strategy, which shall—

"(1) have the long-term goal of stabilization of greenhouse gas concentrations;

"(2) build on the 4 key elements;

"(3) be developed on the basis of an examination of a broad range of emission reduction targets and implementation dates (including those contemplated by the United Nations Framework Convention on Climate Change, done at New York on May 9, 1992) that culminate in the stabilization of greenhouse gas concentrations;

"(4) incorporate mitigation approaches to reduce, avoid, and sequester greenhouse gas emissions;

"(5) include an evaluation of whether and how each emission reduction target and implementation date achieves the emission reductions in an economically and environmentally sound manner;

"(6) be consistent with the goals of energy, transportation, industrial, agricultural, forestry, environmental, and other relevant policies of the United States;

"(7) have a scope that considers the totality of United States public, private, and public-private sector actions that bear on the long-term goal;

"(8) be based on an evaluation of a wide range of approaches for achieving the long-term goal, including evaluation of—

"(A) a variety of cost-effective Federal and State policies, programs, standards, and incentives;

"(B) policies that integrate and promote innovative, market-based solutions in the United States and in foreign countries; and

"(C) participation in other international institutions, or in the support of international activities, that are established or conducted to facilitate stabilization of greenhouse gas concentrations;

"(9) in the final recommendations of the Strategy, emphasize response strategies that achieve the long-term goal and provide specific recommendations concerning—

"(A) measures determined to be appropriate for short-term implementation, giving preference to cost-effective and technologically feasible measures that will—

"(i) produce measurable net reductions in United States emissions that lead toward achievement of the long-term goal; and

"(ii) minimize any adverse short-term and long-term economic and social impacts on the United States;

"(B) the development of technologies that have the potential for long-term implementation—

"(i) giving preference to technologies that have the potential to reduce significantly the overall cost of stabilization of greenhouse gas concentrations; and

"(ii) considering a full range of energy sources, energy conversion and use technologies, and efficiency options;

"(C) such changes in institutional and technology systems as are necessary to adapt to climate change in the short term and the long term;

"(D) such review, modification, and enhancement of the scientific, technical, and economic research efforts of the United States, and improvements to the data resulting from research, as are appropriate to improve the accuracy of predictions concerning climate change and the economic and social costs and opportunities relating to climate change; and

"(E) changes that should be made to project and grant evaluation criteria under other Federal research and development programs so that those criteria do not inhibit development of climate-friendly technologies;

"(10) be developed in a manner that provides for meaningful participation by, and consultation among, Federal, State, tribal, and local government agencies, nongovernmental organizations, academia, scientific bodies, industry, the public, and other interested parties in accordance with subsections (b)(4)(C)(iv)(II) and (d)(3)(B)(iii) of section 1623;

"(11) address how the United States should engage State, tribal, and local governments in developing and carrying out a response to climate change;

"(12) promote, to the maximum extent practicable, public awareness, outreach, and information-sharing to further the understanding of the full range of climate change-related issues;

"(13) include recommendations for legislative and administrative actions necessary to implement the Strategy;

"(14) serve as a framework for climate change response actions by all Federal agencies;

"(15) recommend which Federal agencies are, or should be, responsible for the various aspects of implementation of the Strategy and any budgetary implications;

"(16) address how the United States should engage foreign governments in developing an international response to climate change; and

"(17) be subject to review by an independent review board in accordance with section 1626.

"(b) SUBMISSION TO CONGRESS.—Not later than 1 year after the date of enactment of this subtitle, the President shall submit to Congress the Strategy.

"(c) UPDATING.—Not later than 2 years after the date of submission of the Strategy to Congress under subsection (b), and at the end of each 2-year period thereafter, the President shall submit to Congress an updated version of the Strategy.

"(d) PROGRESS REPORTS.—Not later than 1 year after the date of submission of the Strategy to Congress under subsection (b), and at the end of each 1-year period thereafter, the President shall submit to Congress a report that—

"(1) describes the progress on implementation of the Strategy; and

"(2) provides recommendations for improvement of the Strategy and the implementation of the Strategy.

"(e) ALIGNMENT WITH ENERGY, TRANSPORTATION, INDUSTRIAL, AGRICULTURAL, FORESTRY, AND OTHER POLICIES.—The President, the Director of the White House Office, the Secretary, and the other members of the Interagency Task Force shall work together to align the actions carried out under the Strategy and actions associated with the energy, transportation, industrial, agricultural, forestry, and other relevant policies of the United States so that the objectives of both the Strategy and the policies are met without compromising the climate change-related goals of the Strategy or the goals of the policies.

"(f) NATIONAL LABORATORY CERTIFICATION.—

"(1) IN GENERAL.—The directors of the major national laboratories of the Department specified in paragraph (3) shall annually meet with the President and individually and simultaneously certify whether the energy technology research and development programs of the United States collectively are technically and financially on a trajectory that is consistent with—

"(A) the directions and progress outlined in the Strategy; and

"(B) the long-term goal of stabilization of greenhouse gas concentrations.

"(2) EFFECT OF NEGATIVE CERTIFICATION.—If the certification described in paragraph (1) is in the negative, the directors shall submit to the President a report that—

"(A) specifies the reasons why the certification is in the negative; and

"(B) describes corrective actions that must be taken so that the certification can be made in the affirmative.

"(3) DIRECTORS OF MAJOR NATIONAL LABORATORIES AFFILIATED WITH SCIENCE AND ENERGY PROGRAMS.—The directors of the national laboratories that shall participate in the certification under this subsection are the director of each of—

"(A) the Argonne National Laboratory;

"(B) the Lawrence Berkeley National Laboratory;

"(C) the National Energy Technology Laboratory;

"(D) the National Renewable Energy Laboratory;

"(E) the Oak Ridge National Laboratory; and

"(F) the Pacific Northwest National Laboratory.

"(4) COORDINATION.—The director of the National Energy Technology Laboratory shall serve as coordinator of the group of the directors of the national laboratories specified in paragraph (3).

"SEC. 1623. NATIONAL OFFICE OF CLIMATE CHANGE RESPONSE OF THE EXECUTIVE OFFICE OF THE PRESIDENT.

"(a) ESTABLISHMENT.—

"(1) IN GENERAL.—There is established, within the Executive Office of the President, the National Office of Climate Change Response.

"(2) FOCUS.—The White House Office shall have the focus of achieving the long-term goal of stabilization of greenhouse gas concentrations while minimizing adverse short-term and long-term economic and social impacts.

"(3) DUTIES.—Consistent with paragraph (2), the White House Office shall—

"(A) establish policies, objectives, and priorities for the Strategy;

"(B) in accordance with subsection (d), establish the Interagency Task Force to serve as the primary mechanism through which the

heads of Federal agencies shall assist the Director of the White House Office in developing and implementing the Strategy;

"(C) to the maximum extent practicable, ensure that the Strategy is based on objective, quantitative analysis, drawing on the analytical capabilities of Federal and State agencies, especially the Center;

"(D) advise the President concerning necessary changes in organization, management, budgeting, and personnel allocation of Federal agencies involved in climate change response activities; and

"(E) notify a Federal agency if the policies and discretionary programs of the agency are not well aligned with, or are not contributing effectively to, the long-term goal of stabilization of greenhouse gas concentrations.

"(b) DIRECTOR OF THE WHITE HOUSE OFFICE.—

"(1) IN GENERAL.—The White House Office shall be headed by a Director, who shall report directly to the President.

"(2) APPOINTMENT.—The Director of the White House Office shall be a qualified individual

appointed by the President, by and with the advice and consent of the Senate.

"(3) TERM; VACANCIES.—

"(A) TERM.—The Director of the White House Office shall be appointed for a term of 4 years.

"(B) VACANCIES.—A vacancy in the position of Director of the White House Office shall be filled in the same manner as the original appointment was made.

"(4) DUTIES OF THE DIRECTOR OF THE WHITE HOUSE OFFICE.—

"(A) STRATEGY.—In accordance with section 1622, the Director of the White House Office shall coordinate the development and updating of the Strategy.

"(B) INTERAGENCY TASK FORCE.—The Director of the White House Office shall serve as Chairperson of the Interagency Task Force.

"(C) ADVISORY DUTIES.—

"(i) CLIMATE, ENERGY, TRANSPORTATION, INDUSTRIAL, AGRICULTURAL, BUILDING, FORESTRY, AND OTHER PROGRAMS.—The Director of the White House Office, using an integrated perspective con-

sidering the totality of actions in the United States, shall advise the President and the heads of Federal agencies on—

"(I) the extent to which United States energy, transportation, industrial, agricultural, forestry, building, and other relevant programs are capable of producing progress on the long-term goal of stabilization of greenhouse gas concentrations; and

"(II) the extent to which proposed or newly created energy, transportation, industrial, agricultural, forestry, building, and other relevant programs positively or negatively affect the ability of the United States to achieve the long-term goal of stabilization of greenhouse gas concentrations.

"(ii) TAX, TRADE, AND FOREIGN POLICIES.—The Director of the White House Office, using an integrated perspective considering the totality of actions in the United States, shall advise the President and the heads of Federal agencies on—

"(I) the extent to which the United States tax policy, trade policy, and foreign policy are capable of producing progress on the long-term goal of stabilization of greenhouse gas concentrations; and

"(II) the extent to which proposed or newly created tax policy, trade policy, and foreign policy positively or negatively affect the ability of the United States to achieve the long-term goal of stabilization of greenhouse gas concentrations.

"(iii) INTERNATIONAL TREATIES.—The Secretary of State, acting in conjunction with the Interagency Task Force and using the analytical tools available to the White House Office, shall provide to the Director of the White House Office an opinion that—

"(I) specifies the economic and environmental costs and benefits of any proposed international treaties or components of treaties that have an

influence on greenhouse gas management; and

"(II) assesses the extent to which the treaties advance the long-term goal of stabilization of greenhouse gas concentrations, while minimizing adverse short-term and long-term economic and social impacts and considering other impacts.

"(iv) CONSULTATION.—

"(I) WITH MEMBERS OF INTERAGENCY TASK FORCE.—To the extent practicable and appropriate, the Director of the White House Office shall consult with all members of the Interagency Task Force and other interested parties before providing advice to the President.

"(II) WITH OTHER INTERESTED PARTIES.—The Director of the White House Office shall establish a process for obtaining the meaningful participation of Federal, State, tribal, and local government agencies, nongovernmental organizations, academia, sci-

entific bodies, industry, the public, and other interested parties in the formulation of advice to be provided to the President.

"(D) PUBLIC EDUCATION, AWARENESS, OUTREACH, AND INFORMATION-SHARING.—The Director of the White House Office, to the maximum extent practicable, shall promote public awareness, outreach, and information-sharing to further the understanding of the full range of climate change-related issues.

"(5) ANNUAL REPORTS.—The Director of the White House Office, in consultation with the Interagency Task Force and other interested parties, shall prepare an annual report for submission by the President to Congress that—

"(A) assesses progress in implementation of the Strategy;

"(B) assesses progress, in the United States and in foreign countries, toward the long-term goal of stabilization of greenhouse gas concentrations;

"(C) assesses progress toward meeting climate change-related international obligations;

"(D) makes recommendations for actions by the Federal Government designed to close any gap between progress-to-date and the measures that are necessary to achieve the long-term goal of stabilization of greenhouse gas concentrations; and

"(E) addresses the totality of actions in the United States that relate to the 4 key elements.

"(6) ANALYSIS.—During development of the Strategy, preparation of the annual reports submitted under paragraph (5), and provision of advice to the President and the heads of Federal agencies, the Director of the White House Office shall place significant emphasis on the use of objective, quantitative analysis, taking into consideration any uncertainties associated with the analysis.

"(c) STAFF.—

"(1) IN GENERAL.—The Director of the White House Office shall employ a professional staff of not more than 25 individuals to carry out the duties of the White House Office.

"(2) INTERGOVERNMENTAL PERSONNEL AND FELLOWSHIPS.—The Director of the White House Office may use the authority provided by the Inter-

governmental Personnel Act of 1970 (42 U.S.C. 4701 et seq.) and subchapter VI of chapter 33 of title 5, United States Code, and fellowships, to obtain staff from academia, scientific bodies, private industry, nongovernmental organizations, other Department programs, other Federal agencies, and national laboratories, for appointments of a limited term.

"(d) INTERAGENCY TASK FORCE.—

"(1) IN GENERAL.—The Director of the White House Office shall establish the United States Climate Change Response Interagency Task Force.

"(2) COMPOSITION.—The Interagency Task Force shall be composed of—

"(A) the Director of the White House Office, who shall serve as Chairperson;

"(B) the Secretary of State;

"(C) the Secretary;

"(D) the Secretary of Commerce;

"(E) the Secretary of the Treasury;

"(F) the Secretary of Transportation;

"(G) the Secretary of Agriculture;

"(H) the Administrator of the Environmental Protection Agency;

"(I) the Administrator of the Agency for International Development;

"(J) the United States Trade Representative;

"(K) the National Security Advisor;

"(L) the Director of the National Economic Council;

"(M) the Chairman of the Council on Environmental Quality;

"(N) the Director of the Office of Science and Technology Policy;

"(O) the Chairperson of the Subcommittee on Global Change Research (which performs the functions of the Committee on Earth and Environmental Sciences established by section 102 of the Global Change Research Act of 1990 (15 U.S.C. 2932)); and

"(P) the heads of such other Federal agencies as the Chairperson determines should be members of the Interagency Task Force.

"(3) STRATEGY.—

"(A) IN GENERAL.—The Interagency Task Force shall serve as the primary forum through which the Federal agencies represented on the Interagency Task Force jointly—

"(i) assist the Director of the White House Office in developing and updating the Strategy; and

"(ii) assist the Director of the White House Office in preparing annual reports under subsection (b)(5).

"(B) REQUIRED ELEMENTS.—In carrying out subparagraph (A), the Interagency Task Force shall—

"(i) take into account the long-term goal and other requirements of the Strategy specified in section 1622(a);

"(ii) give full consideration to the facts and opinions presented by the members of the Interagency Task Force;

"(iii) consult with State, tribal, and local government agencies, nongovernmental organizations, academia, scientific bodies, industry, the public, and other interested parties; and

"(iv) build consensus around a Strategy that is based on strong scientific, technical, and economic analyses.

"(4) WORKING GROUPS.—The Chairperson of the Interagency Task Force may establish such top-

ical working groups as are necessary to carry out the duties of the Interagency Task Force.

"(e) PROVISION OF SUPPORT STAFF.—In accordance with procedures established by the Chairperson of the Interagency Task Force, the Federal agencies represented on the Interagency Task Force shall provide staff from the agencies to support information, data collection, and analyses required by the Interagency Task Force.

"(f) HEARINGS.—On request of the Chairperson, the Interagency Task Force may hold such hearings, meet and act at such times and places, take such testimony, and receive such evidence as the Interagency Task Force considers to be appropriate.

"SEC. 1624. TECHNOLOGY INNOVATION PROGRAM IMPLEMENTED THROUGH THE OFFICE OF CARBON MANAGEMENT OF THE DEPARTMENT OF ENERGY AND THE CENTER FOR STRATEGIC CLIMATE CHANGE RESPONSE.

"(a) ESTABLISHMENT OF OFFICE OF CARBON MANAGEMENT OF THE DEPARTMENT OF ENERGY.—

"(1) IN GENERAL.—There is established, within the Department, the Office of Carbon Management.

"(2) DUTIES.—The Department Office shall—

"(A) manage an energy technology research and development program that directly supports the Strategy by—

"(i) focusing on high-risk, bold, breakthrough technologies that—

"(I) are critical to the long-term stabilization of greenhouse gas concentrations;

"(II) are not significantly addressed by other Federal programs; and

"(III) move technology substantially beyond the state of usual innovation;

"(ii) forging fundamentally new research and development partnerships among various Departments, other Federal, and State programs, particularly between basic science and energy technology programs, in cases in which such partnerships have significant potential to affect the ability of the United States to achieve stabilization of greenhouse gas concentrations at the lowest possible cost;

"(iii) forging international research and development partnerships that are in the interests of the United States and make progress on stabilization of greenhouse gas concentrations;

"(iv) making available, through monitoring, experimentation, and analysis, data that are essential to proving the technical and economic viability of technology central to addressing climate change; and

"(v) transitioning research and development programs to other program offices of the Department once such a research and development program crosses the threshold of high-risk research and moves into the realm of more conventional technology development;

"(B) in accordance with subsection (b)(5)(C), prepare a 10-year program plan for the activities of the Department Office and update the plan biennially;

"(C) prepare annual reports in accordance with subsection (b)(6);

"(D) identify the total contribution of all Department programs to climate change response;

"(E) provide substantial analytical support to the White House Office, particularly support in the development of the Strategy and associated progress reporting; and

"(F) advise the Secretary on climate change-related issues, including necessary changes in Department organization, management, budgeting, and personnel allocation in the programs involved in climate change response-related activities.

"(b) DIRECTOR OF THE DEPARTMENT OFFICE.—

"(1) IN GENERAL.—The Department Office shall be headed by a Director, who shall report directly to the Secretary.

"(2) APPOINTMENT.—The Director of the Department Office shall be an employee of the Federal Government who is a qualified individual appointed by the President.

"(3) TERM.—The Director of the Department Office shall be appointed for a term of 4 years.

"(4) VACANCIES.—A vacancy in the position of the Director of the Department Office shall be filled

in the same manner as the original appointment was made.

"(5) DUTIES OF THE DIRECTOR OF THE DEPARTMENT OFFICE.—

"(A) STRATEGY.—The Director of the Department Office shall support development of the Strategy through the provision of staff and analytical support.

"(B) INTERAGENCY TASK FORCE.—Through active participation in the Interagency Task Force, the Director of the Department Office shall—

"(i) based on the analytical capabilities of the Department Office and the Center, share analyses of alternative climate change response strategies with other members of the Interagency Task Force to assist all members in understanding—

"(I) the scale of the climate change response challenge; and

"(II) how the actions of the Federal agencies of the members positively or negatively contribute to climate change solutions; and

"(ii) determine how the energy technology research and development program described in subsection (a)(2)(A) can be designed for maximum impact on the long-term goal of stabilization of greenhouse gas concentrations.

"(C) 10-YEAR PROGRAM PLAN.—

"(i) IN GENERAL.—Not later than 1 year after the date of enactment of this subtitle, the Director of the Department Office shall prepare a 10-year program plan.

"(ii) REQUIRED ELEMENTS.—The plan shall—

"(I) consider all elements of the Strategy that relate to technology research and development;

"(II) become an integral component of the Strategy;

"(III) focus the activities of the Department Office on gaps identified by the Strategy;

"(IV) emphasize the funding of activities that meet the goals de-

scribed in clauses (i) through (iv) of subsection (a)(2)(A);

"(V) identify creative and innovative approaches for building partnerships and managing research and development that have the potential to result in significant advances of technologies and other innovative actions; and

"(VI) place a high level of emphasis on bold, breakthrough research and development programs that can—

"(aa) be created with the involvement of 1 or more Federal research and development programs; and

"(bb) upon reaching a sufficient level of technological maturity, be transitioned to other program offices of the Department without loss of the creative management approaches and partnerships of the innovative research and development programs.

"(iii) SUBMISSION OF PLAN.—The Secretary shall submit the 10-year program plan to Congress and the Director of the White House Office.

"(iv) UPDATING.—

"(I) IN GENERAL.—The Director of the Department Office shall update the 10-year program plan biennially.

"(II) SUBMISSION.—The Secretary shall submit each updated 10-year program plan to Congress and the Director of the White House Office.

"(D) CENTER.—

"(i) OPERATING MODEL.—The Director of the Department Office shall establish an operating model for the Center.

"(ii) DELEGATION OF DEPARTMENT OFFICE FUNCTIONS.—The Director of the Department Office may choose to delegate selected program management and research and development functions of the Department Office to the Center.

"(iii) FOCUS.—

"(I) IN GENERAL.—Funds for the Center should be used to build a Center with focused capability that has a limited number of focused off-site locations.

"(II) INVOLVEMENT OF ORGANIZATIONS.—Notwithstanding subclause (I), the Director of the Department Office may involve any number of organizations in the operation of the Center.

"(iv) TOOLS, DATA, AND CAPABILITIES.—The Director of the Department Office shall foster the development of tools, data, and capabilities at the Center to ensure that—

"(I) the United States has a robust capability for evaluating alternative climate change response scenarios; and

"(II) the Center provides long-term analytical continuity during the terms of service of successive Presidents.

"(E) ADVISORY DUTIES.—The Director of the Department Office shall advise the Secretary on all aspects of climate change response.

"(6) ANNUAL REPORTS.—The Director of the Department Office shall prepare an annual report for submission by the Secretary to Congress and the White House Office that—

"(A) assesses progress toward meeting the goals of the energy technology research and development program described in subsection (a)(2)(A);

"(B) assesses the activities of the Center;

"(C) assesses the contributions of all energy technology research and development programs of the Department (including science programs) to the long-term goal and other requirements of the Strategy specified in section 1622(a); and

"(D) makes recommendations for actions by the Department and other Federal agencies to address the components of technology development that are necessary to support the Strategy.

"(7) ANALYSIS.—During development of the Strategy, the 10-year program plan submitted under paragraph (5)(C), annual reports submitted under paragraph (6), and advice to the Secretary, the Director of the Department Office shall place significant emphasis on the use of objective, quantitative analysis, taking into consideration any associated uncertainties.

"(c) STAFF.—The Director of the Department Office shall employ a professional staff of not more than 25 individuals to carry out the duties of the Department Office.

"(d) INTERGOVERNMENTAL PERSONNEL AND FELLOWSHIPS.—The Department Office may use the authority provided by the Intergovernmental Personnel Act of 1970 (42 U.S.C. 4701 et seq.) and subchapter VI of chapter 33 of title 5, United States Code, and fellowships, to obtain staff from academia, scientific bodies, private industry, nongovernmental organizations, other Department programs, other Federal agencies, and national laboratories, for appointments of a limited term.

"(e) CENTER FOR STRATEGIC CLIMATE CHANGE RESPONSE.—

"(1) IN GENERAL.—

"(A) ESTABLISHMENT.—There is established the Center for Strategic Climate Change

Response, which shall report to the Director of the Department Office.

"(B) LOCATIONS.—The Center shall maintain 1 headquarters location and such additional temporary or permanent locations as are necessary to carry out the duties of the Center.

"(C) CENTER DIRECTOR.—The Center shall be headed by a Director, who shall be selected by the Director of the Department Office.

"(2) DUTIES.—

"(A) IN GENERAL.—

"(i) GOAL.—The Center shall foster the development and application of advanced computational tools, data, and capabilities that support integrated assessment of alternative climate change response scenarios and implementation of the Strategy.

"(ii) PARTICIPATION AND SUPPORT.—The Center may include participation of, and be supported by, each other Federal agency that has a direct or indirect role in the development, commercialization, or transfer of energy, transportation, indus-

trial, agricultural, forestry, or other climate change-related technology.

"(B) PROGRAMS.—

"(i) IN GENERAL.—The Center shall—

"(I) develop and maintain core analytical competencies and complex, integrated computational modeling capabilities that are necessary to support the design and implementation of the Strategy;

"(II) track United States and international progress toward the long-term goal of stabilization of greenhouse gas concentrations; and

"(III) in support of the Department Office, support the management and implementation of research and development programs.

"(ii) INTERNATIONAL CARBON DIOXIDE SEQUESTRATION MONITORING AND DATA PROGRAM.—In consultation with Federal, State, academic, scientific, private sector, nongovernmental, tribal, and international carbon capture and sequestration

technology programs, the Center shall design and carry out an international carbon dioxide sequestration monitoring and data program to collect, analyze, and make available the technical and economic data to ascertain—

"(I) whether engineered sequestration and terrestrial sequestration will be acceptable technologies from regulatory, economic, and international perspectives;

"(II) whether carbon dioxide sequestered in geological formations or ocean systems is stable and has inconsequential leakage rates on a geologic time-scale; and

"(III) the extent to which forest, agricultural, and other terrestrial systems are suitable carbon sinks.

"(C) AREAS OF EXPERTISE.—

"(i) IN GENERAL.—The Center shall develop and maintain expertise in integrated assessment, modeling, and related capabilities necessary—

"(I) to understand the relationship between natural, agricultural, industrial, energy, and economic systems;

"(II) to design effective research and development programs; and

"(III) to develop and implement the Strategy.

"(ii) TECHNOLOGY TRANSFER AND DIFFUSION.—The expertise described in clause (i) shall include knowledge of technology transfer and technology diffusion in United States markets and foreign markets.

"(D) DISSEMINATION OF INFORMATION.—The Center shall ensure, to the maximum extent practicable, that technical and scientific knowledge relating to greenhouse gas emission reduction, avoidance, and sequestration is broadly disseminated through publications, fellowships, and training programs.

"(E) ASSESSMENTS.—In a manner consistent with the Strategy, the Center shall conduct assessments of deployment of climate-friendly technology.

"(F) USE OF PRIVATE SECTOR FUNDING.—

"(i) IN GENERAL.—The Center shall create an operating model that allows for collaboration, division of effort, and cost sharing with industry on individual climate change response projects.

"(ii) REQUIREMENTS.—Although cost sharing in some cases may be appropriate, the Center shall focus on long-term high-risk research and development and should not make industrial partnerships or cost sharing a requirement, if such a requirement would bias the activities of the Center toward incremental innovations.

"(iii) REEVALUATION ON TRANSITION.—At such time as any bold, breakthrough research and development program reaches a sufficient level of technological maturity such that the program is transitioned to a program office of the Department other than the Department Office, the cost-sharing requirements and criteria applicable to the program should be reevaluated.

"(iv) PUBLICATION IN FEDERAL REGISTER.—Each cost-sharing agreement entered into under this subparagraph shall be published in the Federal Register.

"(G) INTERGOVERNMENTAL PERSONNEL AND FELLOWSHIPS.—The Director of the Center may use the authority provided by the Intergovernmental Personnel Act of 1970 (42 U.S.C. 4701 et seq.) and subchapter VI of chapter 33 of title 5, United States Code, and fellowships, to obtain staff from academia, scientific bodies, private industry, nongovernmental organizations, other Department programs, other Federal agencies, and national laboratories, for appointments of a limited term.

"SEC. 1625. ADDITIONAL OFFICES AND ACTIVITIES.

"The Secretary of Agriculture, the Secretary of Transportation, the Administrator of the Environmental Protection Agency, and the heads of other Federal agencies may establish such offices and carry out such activities, in addition to those established or authorized by this subtitle, as are necessary to carry out this subtitle.

"SEC. 1626. UNITED STATES CLIMATE CHANGE RESPONSE STRATEGY REVIEW BOARD.

"(a) ESTABLISHMENT.—There is established as an independent establishment within the executive branch the United States Climate Change Response Strategy Review Board.

"(b) MEMBERSHIP.—

"(1) COMPOSITION.—The Review Board shall consist of 11 members who shall be appointed, not later than 90 days after the date of enactment of this subtitle, by the President by and with the advice and consent of the Senate, from among qualified individuals nominated by the National Academy of Sciences in accordance with paragraph (2).

"(2) NOMINATIONS.—Not later than 60 days after the date of enactment of this subtitle, after taking into strong consideration the guidance and recommendations of a broad range of scientific and technical societies that have the capability of recommending qualified individuals, the National Academy of Sciences shall nominate for appointment to the Review Board not fewer than 22 individuals who—

"(A) are—

"(i) qualified individuals; or

"(ii) experts in a field of knowledge specified in section 1621(9)(B); and

"(B) as a group represent broad, balanced expertise.

"(3) PROHIBITION ON FEDERAL GOVERNMENT EMPLOYMENT.—A member of the Review Board shall not be an employee of the Federal Government.

"(4) TERMS; VACANCIES.—

"(A) TERMS.—

"(i) IN GENERAL.—Subject to clause (ii), each member of the Review Board shall be appointed for a term of 4 years.

"(ii) INITIAL TERMS.—

"(I) COMMENCEMENT DATE.—The term of each member initially appointed to the Review Board shall commence 120 days after the date of enactment of this subtitle.

"(II) TERMINATION DATE.—Of the 11 members initially appointed to the Review Board, 5 members shall be appointed for a term of 2 years and 6 members shall be appointed for a term of 4 years, to be designated by the President at the time of appointment.

"(B) VACANCIES.—

"(i) IN GENERAL.—A vacancy on the Review Board shall be filled in the manner described in this subparagraph.

"(ii) NOMINATIONS BY THE NATIONAL ACADEMY OF SCIENCES.—Not later than 60 days after the date on which a vacancy commences, the National Academy of Sciences shall—

"(I) after taking into strong consideration the guidance and recommendations of a broad range of scientific and technical societies that have the capability of recommending qualified individuals, nominate, from among qualified individuals, not fewer than 2 individuals to fill the vacancy; and

"(II) submit the names of the nominees to the President.

"(iii) SELECTION.—Not later than 30 days after the date on which the nominations under clause (ii) are submitted to the President, the President shall select from among the nominees an individual to fill the vacancy.

"(iv) SENATE CONFIRMATION.—An individual appointed to fill a vacancy on the Review Board shall be appointed by and with the advice and consent of the Senate.

"(5) DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST.—

"(A) EMPLOYMENT OF NOMINEES.—If a nominee to the Review Board is employed by an entity that receives any funding from the Department or any other Federal agency, the fact of the employment shall be—

"(i) disclosed to the President by the National Academy of Sciences at the time of the nomination; and

"(ii) publicly disclosed by the nominee as part of the Senate confirmation process of the nominee.

"(B) EMPLOYMENT OF MEMBERS.—If, during the period of service of a member on the Review Board, the member is employed by an entity that receives any funding from the Department or any other Federal agency, the fact of the employment shall be publicly disclosed by

the Chairperson of the Review Board on a semi-annual basis.

"(C) FINANCIAL BENEFIT TO MEMBERS.—If, during the period of service of a member on the Review Board, the Review Board makes any written recommendation that may financially benefit a member or an entity that employs the member, the fact of that financial benefit shall be publicly disclosed by the Chairperson of the Review Board at the time of the recommendation.

"(D) APPLICABILITY OF ETHICS IN GOVERNMENT ACT OF 1978.—A member of the Review Board shall be deemed to be an individual subject to the Ethics in Government Act of 1978 (5 U.S.C. App.).

"(6) CHAIRPERSON; VICE CHAIRPERSON.—The members of the Review Board shall select a Chairperson and a Vice Chairperson of the Review Board from among the members of the Review Board.

"(c) DUTIES.—

"(1) IN GENERAL.—Not later than 180 days after the date of submission of the initial Strategy under section 1622(b), each updated version of the Strategy under section 1622(c), each progress report

under section 1622(d), and each national laboratory certification under section 1622(f), the Review Board shall submit to the President, Congress, and the heads of Federal agencies as appropriate a report assessing the adequacy of the Strategy, report, or certification.

"(2) COMMENTS.—In reviewing the Strategy, or a report or certification, under paragraph (1), the Review Board shall consider and comment on—

"(A) the adequacy of effort and the appropriateness of focus of the totality of all public, private, and public-private sector actions of the United States with respect to the 4 key elements;

"(B) the extent to which actions of the United States, with respect to climate change, complement or leverage international research and other efforts designed to manage global emissions of greenhouse gases, to further the long-term goal of stabilization of greenhouse gas concentrations;

"(C) the funding implications of any recommendations made by the Review Board; and

"(D)(i) the effectiveness with which each Federal agency is carrying out the responsibil-

ities of the Federal agency with respect to the short-term and long-term greenhouse gas management goals; and

"(ii) the adequacy of the budget of each such Federal agency to carry out those responsibilities.

"(3) ADDITIONAL RECOMMENDATIONS.—

"(A) IN GENERAL.—Subject to subparagraph (B), the Review Board, at the request of the President or Congress, may provide recommendations on additional climate change-related topics.

"(B) SECONDARY DUTY.—The provision of recommendations under subparagraph (A) shall be a secondary duty to the primary duty of the Review Board of providing independent review of the Strategy and the reports and certifications under paragraphs (1) and (2).

"(d) POWERS.—

"(1) HEARINGS.—

"(A) IN GENERAL.—On request of the Chairperson or a majority of the members of the Review Board, the Review Board may hold such hearings, meet and act at such times and places, take such testimony, and receive such

evidence as the Review Board considers to be appropriate.

"(B) ADMINISTRATION OF OATHS.—Any member of the Review Board may administer an oath or affirmation to any witness that appears before the Review Board.

"(2) PRODUCTION OF DOCUMENTS.—

"(A) IN GENERAL.—On request of the Chairperson or a majority of the members of the Review Board, and subject to applicable law, the Secretary or head of a Federal agency represented on the Interagency Task Force, or a contractor of such an agency, shall provide the Review Board with such records, files, papers, data, and information as are necessary to respond to any inquiry of the Review Board under this subtitle.

"(B) INCLUSION OF WORK IN PROGRESS.—Subject to applicable law, information obtainable under subparagraph (A)—

"(i) shall not be limited to final work products; but

"(ii) shall include draft work products and documentation of work in progress.

"(3) POSTAL SERVICES.—The Review Board may use the United States mails in the same manner and under the same conditions as other agencies of the Federal Government.

"(e) COMPENSATION OF MEMBERS.—A member of the Review Board shall be compensated at a rate equal to the daily equivalent of the annual rate of basic pay prescribed for level IV of the Executive Schedule under section 5315 of title 5, United States Code, for each day (including travel time) during which the member is engaged in the performance of the duties of the Review Board.

"(f) TRAVEL EXPENSES.—A member of the Review Board shall be allowed travel expenses, including per diem in lieu of subsistence, at rates authorized for an employee of an agency under subchapter I of chapter 57 of title 5, United States Code, while away from the home or regular place of business of the member in the performance of the duties of the Review Board.

"(g) STAFF.—

"(1) IN GENERAL.—The Chairperson of the Review Board may, without regard to the civil service laws (including regulations), appoint and terminate an executive director and such other additional personnel as are necessary to enable the Review Board to perform the duties of the Review Board.

"(2) CONFIRMATION OF EXECUTIVE DIRECTOR.—The employment of an executive director shall be subject to confirmation by the Review Board.

"(3) COMPENSATION.—

"(A) IN GENERAL.—Except as provided in subparagraph (B), the Chairperson of the Review Board may fix the compensation of the executive director and other personnel without regard to the provisions of chapter 51 and subchapter III of chapter 53 of title 5, United States Code, relating to classification of positions and General Schedule pay rates.

"(B) MAXIMUM RATE OF PAY.—The rate of pay for the executive director and other personnel shall not exceed the rate payable for level V of the Executive Schedule under section 5316 of title 5, United States Code.

"(h) PROCUREMENT OF TEMPORARY AND INTERMITTENT SERVICES.—The Chairperson of the Review Board may procure temporary and intermittent services in accordance with section 3109(b) of title 5, United States Code, at rates for individuals that do not exceed the daily equivalent of the annual rate of basic pay prescribed for level V of the Executive Schedule under section 5316 of that title.

"SEC. 1627. AUTHORIZATION OF APPROPRIATIONS.

"(a) WHITE HOUSE OFFICE.—

"(1) USE OF AVAILABLE APPROPRIATIONS.—From funds made available to Federal agencies for the fiscal year in which this subtitle is enacted, the President shall provide such sums as are necessary to carry out the duties of the White House Office under this subtitle until the date on which funds are made available under paragraph (2).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the White House Office to carry out the duties of the White House Office under this subtitle $5,000,000 for each of fiscal years 2002 through 2011, to remain available through September 30, 2011.

"(b) DEPARTMENT OFFICE.—

"(1) USE OF AVAILABLE APPROPRIATIONS.—From funds made available to Federal agencies for the fiscal year in which this subtitle is enacted, the President shall provide such sums as are necessary to carry out the duties of the Department Office under this subtitle until the date on which funds are made available under paragraph (2).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Department Office to carry out the duties of the De-

partment Office under this subtitle $4,000,000,000 for the period of fiscal years 2002 through 2011, to remain available through September 30, 2011.

"(c) CENTER.—

"(1) USE OF AVAILABLE APPROPRIATIONS.—From funds made available to Federal agencies for the fiscal year in which this subtitle is enacted, the President shall provide such sums as are necessary to carry out the duties of the Center under this subtitle until the date on which funds are made available under paragraph (2).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Center to carry out the duties of the Center under this subtitle $75,000,000 for each of fiscal years 2002 through 2011, to remain available through September 30, 2011.

"(d) REVIEW BOARD.—

"(1) USE OF AVAILABLE APPROPRIATIONS.—From funds made available to Federal agencies for the fiscal year in which this subtitle is enacted, the President shall provide such sums as are necessary to carry out the duties of the Review Board under this subtitle until the date on which funds are made available under paragraph (2).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Review Board to carry out the duties of the Review Board under this subtitle $3,000,000 for each of fiscal years 2002 through 2011, to remain available until expended.

"(e) ADDITIONAL AMOUNTS.—Amounts authorized to be appropriated under this section shall be in addition to—

"(1) amounts made available to carry out the United States Global Change Research Program under the Global Change Research Act of 1990 (15 U.S.C. 2921 et seq.); and

"(2) amounts made available under other provisions of law for energy research and development.".

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