BUILDING AMERICA'S CLEAN FUTURE: PATHWAYS TO DECARBONIZE THE ECONOMY

HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT AND CLIMATE CHANGE

OF THE

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HOUSE OF REPRESENTATIVES

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BUILDING AMERICA'S CLEAN FUTURE: PATHWAYS TO DECARBONIZE THE ECONOMY

WEDNESDAY, JULY 24, 2019

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT AND CLIMATE CHANGE,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 10:00 a.m., in the John D. Dingell Room 2123, Rayburn House Office Building, Hon. Paul Tonko (chairman of the subcommittee) presiding.

Members present: Representatives Tonko, Clarke, Peters, Barragán, McEachin, Blunt Rochester, Soto, DeGette, Matsui, McNerney, Ruiz, Dingell, Pallone (ex officio), Shimkus (subcommittee ranking member), Rodgers, McKinley, Johnson, Long, Flores, Mullin, Carter, Duncan, and Walden (ex officio).

Staff present: Adam Fischer, Policy Analyst; Jean Fruci, Energy and Environment Policy Advisor; Caitlin Haberman, Professional Staff Member; Rick Kessler, Senior Advisor and Staff Director, Energy and Environment; Brendan Larkin, Policy Coordinator; Dustin Maghamfar, Air and Climate Counsel; Mike Bloomquist, Minority Staff Director; Adam Buckalew, Minority Director of Coalitions and Deputy Chief Counsel, Health; Jordan Davis, Minority Senior Advisor; Mary Martin, Minority Chief Counsel, Energy and Environment and Climate Change; Brandon Mooney, Minority Deputy Chief Counsel, Energy; Brannon Rains, Minority Staff Assistant; and Peter Spencer, Minority Senior Professional Staff Member, Environment and Climate Change.

Mr. TONKO. The Subcommittee on Environment and Climate Change will now come to order.

Today, we are proceeding in a slightly different order. Chairman Pallone and I will each speak for no more than four minutes so that we can yield to the gentleman from Virginia, Mr. McEachin, two minutes after Chairman Pallone has spoken. I recognize myself for four minutes for the purpose of an opening statement.

OPENING STATEMENT OF HON. PAUL TONKO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Yesterday, I joined Chairman Pallone, Energy Subcommittee Chairman Rush, and other members of the committee to announce support for a 100 percent clean economy by no later than 2050.

Congress is looking to this committee to take a leading role in developing the policies to achieve a net zero greenhouse gas emissions result.

This must include significant direct emissions reductions in every community, and the just and equitable transition for every American including adversely impacted individuals and communities.

This is the first in a series of hearings to study the challenges and potential solutions before us. One thing is clear. We cannot afford to wait until 2050 or even 2030 to act.

We must be prepared for the earliest opportunity with a plan that can garner support from a very broad coalition. After 10 years of congressional inaction, today no consensus exists on the best policies to achieve this scientifically necessary target.

But we have the benefit of a panel of expert witnesses who can discuss effective pathways for decarbonization. I believe there is a broad agreement that our decarbonization strategy should seek to improve energy efficiency, deploy new and preserve existing clean electricity resources, enable electrification across all sectors of our economy, and utilize carbon dioxide removal through natural and technological methods.

This core strategy will not capture all greenhouse gas emissions. We will also need development of cleaner fuels for heavy duty transportation and new materials and processes for industrial applications.

We also acknowledge that any meaningful climate action will require significant federal investments; particularly in rural, deindustrialized, and environmental justice communities, which will create new economic opportunities and accelerate the transition to a clean energy future for all.

Despite apparent agreement on this overall strategy of decarbonization, there is little consensus on which specific policy mechanisms would be most effective and fair to achieve it.

No single policy will deliver America's transition to a 100 percent clean economy on its own. Congress must develop economy wide and sector-specific solutions, and we should be clear. This target requires nothing short of transforming the United States economy.

If we can limit economic disruptions and expand opportunities in the process we should do so. Throughout this process, we will consider how deep decarbonization may impact communities and workers, equity and environmental justice, energy affordability and United States competitiveness, and processes that are difficult to decarbonize.

But we must also keep this simple fact in mind. Comprehensive climate action will create millions of good-paying jobs, building a clean energy and climate resilient economy while reducing harmful pollution.

Efforts to rebuild and modernize our infrastructure, research and deploy clean technologies, promote workforce development, and ensure safe and healthy communities will strengthen American global competitiveness and economic leadership throughout the 21st century.

The work we do here will impact millions of Americans for generations to come. We have committed to ensuring this process will be open to all ideas and thoughtful in its response.

We have already engaged with numerous stakeholders and committed to them that they have a seat at this table. A collaborative open approach is the only way to ensure America's climate transition is not only possible but also just and equitable.

I look forward to today's discussion as well as a rigorous, open, and honest exploration of the potential solutions in the months ahead to put America on the pathway to a clean economy.

[The prepared statement of Mr. Tonko follows:]

PREPARED STATEMENT OF HON. PAUL TONKO

Yesterday I joined Chairman Pallone, Energy Subcommittee Chairman Rush, and other Members of the Committee to announce support for a 100% Clean Economy by no later than 2050.

Congress is looking to this Committee to take a leading role in developing the policies to achieve net-zero greenhouse gas emissions. This must include significant direct emissions reductions in every community, and a just and equitable transition for every American, including adversely impacted individuals and communities.

This is the first in a series of hearings to study the challenges and potential solutions before us. One thing is clear, we cannot afford to wait until 2050, or even 2030, to act. We must be prepared for the earliest opportunity with a plan that can garner support from a broad coalition.

After 10 years of Congressional inaction, today no consensus exists on the best policies to achieve this scientifically necessary target.

But we have the benefit of a panel of expert witnesses who can discuss effective pathways for decarbonization. I believe there is broad agreement that our decarbonization strategy should seek to improve energy efficiency; deploy new and preserve existing clean electricity resources; enable electrification across all sectors of the economy; and utilize carbon dioxide removal through natural and technological methods.

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Despite apparent agreement on this overall strategy of decarbonization, there is little consensus on which specific policy mechanisms would be most effective and fair to achieve it.

No single policy will deliver America's transition to a 100% clean economy on its own. Congress must develop economy-wide and sector-specific solutions.

And we should be clear—this target requires nothing short of transforming the U.S. economy. If we can limit economic disruptions and expand opportunities in the process, we should do so.

Throughout this process, we will consider how deep decarbonization may impact communities and workers, equity and environmental justice, energy affordability and U.S. competitiveness, and processes that are difficult to decarbonize.

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I look forward to today's discussion as well as a rigorous, open, and honest exploration of the potential solutions in the months ahead to put America on the pathway to a clean economy.

Mr. TONKO. With that, I now recognize Mr. Shimkus, our ranking member of the Subcommittee on Environment and Climate Change, for five minutes for his opening statement.

OPENING STATEMENT OF HON. JOHN SHIMKUS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Mr. SHIMKUS. Thank you, Mr. Chairman.

This hearing kicks off the subcommittee's review of policies that would aim to substantially reduce greenhouse gas emissions across the United States economy.

The goals of what is called deep decarbonization are bold and would sweep across every aspect of our society. The most aggressive of them call for regulatory schemes to achieve net zero emissions by 2050 and would change how we generate electricity, fuel our vehicles, grow our food, and make the steel and cement and other ingredients of modern infrastructure, cities, and industry.

As we examine deep decarbonization policies, I hope we can keep appropriate perspectives. For example, we should be clear that some of these goals are not possible to achieve with current technology or through renewable energy alone.

Some are too expensive to implement in any way that would preserve affordable energy and the goods and services we rely upon in our daily lives.

We have to take a hard look at the full costs of domestic policies that would transform our electric infrastructure, our energy systems, and our mobility.

Hearings like this can help start to shine the light on all of these. We also should recognize that we are talking about a global issue. As noted in the previous hearings, there has been unrelenting growth in global carbon emissions-even as the U.S. emissions have declined.

While projections show global emissions growth may level off, they will not decline very much as nations continue to seek the tremendous benefits of energy, power, and transportation in their societies as they continue to acquire the steel, cement, and other infrastructure needed for building and expanding.

This is particularly true for China, India, and the rest of the developing world. Affordable energy and industrial output are key ingredients for these growing economies.

The plain fact is: the world, according to projections by the International Energy Agency, will continue to rely primarily on fossil forms of energy for the foreseeable future and the developing world will continue to dominate global emissions in the years to come.

The policies we consider in the United States should be considered against this global energy and economic reality. We should not put the United States at a competitive disadvantage to other nations or deprive our nation important opportunities to innovate and develop the new fossil, or nuclear technologies or industrial technologies that promise clean future energy systems.

Focusing on global energy and economic realities will help us focus on where the real gains can be achieved in reducing future emissions and maintaining the prosperity necessary for addressing future climate risks.

Let me suggest that these gains will come less from radically and expensively transforming a mature $20 trillion U.S. economy than providing the modern, clean, and low-emission technologies to nations still putting their modern economies into place.

In recent months, we have been building a record that underscores the critical need for technological breakthroughs to develop cleaner energy and economic systems.

This morning, we will hear from witnesses who can speak to what is necessary to move these technological breakthroughs forward, and we welcome you.

I am particularly looking forward to hearing from Shannon Angielski of the Carbon Utilization Council. She will speak to the contribution of fossil fuel technologies to decarbonization objectives and she can outline how bipartisan work in Congress has helped create new markets and what more is needed to ensure that these policies are effective.

The bottom line is there are practical policies we can pursue in a bipartisan fashion that will help incentivize the development of innovative technologies for coal and natural gas as well as nuclear energy that will strengthen American leadership in these critical sectors.

We should avoid complex, regulatory, and command and control schemes that the majority sometimes seeks to impose. These would foreclose the potential for innovations that will enable full use of our nation's tremendous energy and economic resources——

Our goals should be to perfect the bipartisan policies that will allow innovation in the private sector to provide the new technologies that will provide the path to lower emissions, especially where this is needed most.

And with that, Mr. Chairman, that ends my opening statement. I yield back.

[The prepared statement of Mr. Shimkus follow:]

Prepared Statement of Hon. John Shimkus

This hearing kicks off the Subcommittee's review of policies that would aim to substantially reduce greenhouse gas emissions across the United States economy.

The goals of what is called "deep" decarbonization are bold and would sweep across every aspect of our society. The most aggressive of them call for regulatory schemes to achieve net-zero emissions by 2050 and would change how we generate electrical power, fuel our vehicles, grow our food, and make the steel and cement and the other ingredients of modern infrastructure, cities, and industry.

As we examine decarbonization policies, I hope we can keep appropriate perspective.

For example, we should be clear that some of these goals are not possible to achieve with current technology-or through renewable energy alone. Some are too expensive to implement in any way that would preserve affordable energy and the goods and services we rely upon in our daily lives.

We have to take a hard look at the full costs of domestic policies that would transform our electric infrastructure, our energy systems, our mobility. Hearings like this can help start to shine a light on this.

We also should recognize that we are talking about a global issue. As noted in previous hearings, there has been unrelenting growth in global carbon emissions—even as the U.S. emissions have declined.

While projections show global emissions growth may level off, they will not decline very much as nations continue to seek the tremendous benefits of energy, power, and transportation in their societies and as they continue to acquire the steel, cement, and other infrastructure needed for building and expanding. This is particularly true for China, India and the rest of the developing world.

Affordable energy and industrial output are key ingredients for these growing economies. The plain fact is: the world, according to projections by the International Energy Agency, will continue to rely primarily on fossil forms of energy for the foreseeable future. And the developing world will continue to dominate global emissions in the years to come.

The policies we consider in the United States should be considered against this global energy and economic reality.

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Let me suggest that these gains will come less from radically and expensively transforming a mature, 20-trillion-dollar U.S. economy than from providing the modern, clean and low emissions technologies to nations still putting their modern economies in place.

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This morning we will hear from witnesses who can speak to what is necessary to move these technological breakthroughs forward.

I am particularly looking forward to hearing from Shannon Angielski of the Carbon Utilization Council, or CURC. She will speak to the contribution of fossil fuel technologies to decarbonization objectives. And she can outline how bipartisan work of Congress has helped create new markets and what more is needed to ensure these policies are effective.

The bottom line is, there are practical policies we can pursue in a bi-partisan fashion that will help incentivize the development of innovative technologies for coal and natural gas, as well as nuclear energy and that will strengthen American leadership in these critical sectors.

We should avoid complex regulatory and command and control schemes that the Majority seeks to impose. These would foreclose the potential for innovations that will enable full use of our nation's tremendous energy and economic resources.

Our goal should be to perfect the bi-partisan polices that allow innovation and private sector to provide the new technologies that will provide the paths to lower emissions, especially where this is needed most.

Mr. TONKO. Thank you. The gentleman yields back.

The Chair now recognizes Mr. Pallone, chairman of the full committee, for four minutes for his opening statement.

OPENING STATEMENT OF HON. FRANK PALLONE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW JERSEY

Mr. PALLONE. Thank you, Chairman Tonko.

One of this committee's top priorities is combating climate change. Yesterday, I joined Chairmen Tonko and Rush and other committee Democrats in announcing a bold plan to address the climate crisis by achieving 100 percent clean economy by 2050.

Our plan is based on the science. International scientific experts tell us we must invest in clean technologies and initiate an aggressive economy wide effort now to achieve this goal.

So yesterday we outlined a process for reaching the goal and that process begins today with this hearing where we will examine the challenges and opportunities that exist for reducing greenhouse gas pollution from the major sectors of our economy.

Recent reports by U.S. scientists and the Intergovernmental Panel on Climate Change paint a grim picture if we do not get carbon pollution under control.

We are already experiencing record flooding, sea level rise, intense wildfires, extended drought, and severe weather events that experts projected would come with increased warming, and I don't have to tell anybody that.

Anybody knows over the weekend the temperature in my district got to 103. We lost power for about 30 to 40 percent of the homes in my home county including my own home, and my wife called me this morning to say the power finally came on at 2:30 a.m.

You know, this is what we are all facing. These events are taking a terrible toll on our communities and we must act. Transforming our economy is no easy task. There will be costs associated with the transformation and the scope. But the costs of inaction are extremely high and rising.

Fortunately, the calls for action continue to grow. This week, 28 global companies representing a combined market capitalization of $1.2 trillion responded to the U.N. call to action by committing to the goal of net zero emissions by 2050, and we will hear from our witnesses this transformation is challenging but not impossible.

We have many technologies available today that with wider deployment can lower carbon and other harmful pollutants in the near term.

Some sectors will present greater challenges and will require new technologies and significant investment to reach net zero. But we want to reward innovation and the businesses that invest in clean technologies.

However, we cannot only focus on business and technologies and hope that individual workers and communities automatically benefit by their adoption. We know that doesn't always happen and that economic transformations can leave people and communities behind.

Workers displaced from lucrative jobs in fossil fuel-dependent industries must be able to find equally profitable jobs in their communities and in new clean industries, and we must reinvest in communities that currently are more exposed to harmful pollution and climate change.

We can use this opportunity to ensure that the economy works for everyone and supports a safe healthy environment.

United States is a leader in innovation but we cannot stay competitive without data technology and infrastructure. We must get ahead in the race to a clean economy. We need to grow now.

Clean industries here employ our workers to deliver modern high-quality products to the world. We have the talent and resources. All we need now is determination to act.

So as we begin this process and, you know, we think of ourselves and we are the innovation committee, I invite everyone to share their ideas with us about how to modernize our infrastructure and transform our economy to reduce carbon pollution, create family-sustaining jobs and lead the world in growing new clean industries, and I look forward to working with all of you as our effort to develop legislation to achieve 100 by '50 moves forward.

And, again, I particularly want to thank our two subcommittee chairs, Mr. Tonko and Mr. Rush. Basically, the 100 by '50 was Mr. Tonko's idea and he has been working for some time, not only the last six months since we have been in the majority but for many years, on this goal and best ways to achieve it.

And so we will see how we develop that over the next few months when we return from the August recess.

Thank you.

[The prepared statement of Mr. Pallone follows:]

PREPARED STATEMENT OF HON. FRANK PALLONE, JR.

One of this Committee's top priorities is combating climate change. Yesterday I joined Chairmen Tonko and Rush, and other Committee Democrats in announcing a bold plan to address the climate crisis by achieving a 100 percent clean economy by 2050.

Our plan is based on the science. International scientific experts tell us we must invest in clean technologies and initiate an aggressive, economy-wide effort now to achieve this goal. So, yesterday we outlined a process for reaching that goal—and that process begins today with this hearing where we will examine the challenges and opportunities that exist for reducing greenhouse gas pollution from the major sectors of our economy.

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We are already experiencing record flooding, sea level rise, intense wildfires, extended drought and severe weather events that experts projected would come with increased warming. These events are taking a terrible toll on our communities, and we must act.

Transforming our economy is no easy task. There will be costs associated with a transformation of this scope, but, the costs of inaction are extremely high and rising.

Fortunately, the calls for action continue to grow. This week, 28 global companies, representing a combined market capitalization of $1.2 trillion, responded to the United Nations call to action by committing to the goal of net zero emissions by 2050.

As we will hear from our witnesses, this transformation is challenging, but not impossible. We have many technologies available today that, with wider deployment, can lower carbon and other harmful pollutants in the near term. Some sectors will present greater challenges and will require new technologies and significant investment to reach net zero. We want to reward innovation and the businesses that invest in clean technologies.

However, we cannot only focus on businesses and technologies and hope that individual workers and communities automatically benefit by their adoption. We know that doesn't always happen and that economic transformations can leave people and communities behind.

Workers displaced from lucrative jobs in fossil-fuel dependent industries must be able to find equally profitable jobs in their communities and in new clean industries. And, we must reinvest in communities that currently are more exposed to harmful pollution and climate change. We can use this opportunity to ensure that the economy works for everyone and supports a safe, healthy environment.

The United States is a leader in innovation, but we cannot stay competitive with outdated technology and infrastructure. We must get ahead in the race to a clean economy. We need to grow new, clean industries here and employ our workers to deliver modern, high quality products to the world. We have the talent and resources. All we need now is the determination to act.

As we begin this process, I invite everyone to share their ideas with us about how to modernize our infrastructure and transform our economy to reduce carbon pollution, create family-sustaining jobs, and lead the world in growing new, clean industries. I look forward to working with all of you as our effort to develop legislation to achieve 100-by-50 moves forward.

Mr. TONKO. Thank you. The gentleman yields back and thank you for your kind words, Chairman.

And the Chair now recognizes Mr. Walden, the ranking member of the full committee, for five minutes for his opening statement.

OPENING STATEMENT OF HON. GREG WALDEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. WALDEN. Well, thank you. Thank you, Mr. Chairman.

Good morning. Thanks for having this hearing. As you all pointed out yesterday, the Democrats held a press conference to outline their plans for decarbonizing the United States by 2050 and today we are reviewing some potential paths to achieve that goal, and that is important.

We need to fully understand what decarbonization means for consumers and for American workers. Republicans support innovation, conservation, adaptation, and preparation.

We support prudent steps to reduce emissions and to address current and future climate risks. These steps require we examine the costs, the effectiveness, and the economic impacts of various solutions proposed to address the risks.

They require we do not undermine the economic priorities of communities and states around the nation. For this reason, we have urged our majority colleagues to avoid resurrecting top-down policies that are costly and harmful.

Taxation and regulation can lead to economic stagnation and hurts consumers and workers. But instead, we'd like them to work with us on bipartisan solutions like those that we have pursued over the last several Congresses with great success.

Those policies have continued America's leadership in developing innovative technologies to produce energy with little or no emissions, and our record on this front is clear and positive for the climate.

Republicans have been working with Democrats over the past several Congresses to remove regulatory barriers to new technological advances in power generation from hydroelectric power to small modular nuclear, from carbon capture and storage incentives to power grid reforms.

As innovation is where the long-term solutions to climate change are, we want America to lead. We want America to lead the world in innovation, as we always have, especially on clean energy and environmental cleanup as well.

Instead of focusing solely on regulations and taxation that mandate emissions reductions in the U.S., we need to put more emphasis on the parts of the world with some of the greatest CO2 emissions like China and India.

Our most effective policies are the ones that encourage and support development of clean energy here at home and abroad by American workers and by innovators.

We can develop these new technologies and we can market them to the world. We support realistic solutions that will have meaningful impact on global emissions while growing the U.S. economy and protecting American workers.

That is why we pursued policies like the 45Q Carbon Sequester tax credit the Republicans enacted last Congress. They offer much in the potential for cleaner fossil fuels and sequester of carbon.

We will hear this morning about the promises carbon capture holds and what might be done to improve its prospects, and we are excited to learn about that. We know there is more innovation just over the horizon in these areas.

We should talk about what it takes to ensure the United States can lead on clean fossil energy technology, and on nuclear technology, and not cede our dominance to our adversarial competitors globally.

We already risk that in the nuclear technology space and we need to make sure that doesn't continue. Closer to home, we have to pursue practical policies that strengthen local economies and make our communities safe.

In my part of the world in the Northwest, we have benefitted from clean hydropower, from wind generation and geothermal and solar power.

We have suffered greatly, though, from the lack of management of our federal forest lands, which are burning up every summer, choking our citizens and polluting our atmosphere.

Actively managing our forests not only reduces the risks of fire, it also reduces carbon emissions, as proven out by the IPCC itself.

It promotes healthy younger strands of trees, maximizes our forests' ability to actively sequester carbon; all this while creating jobs and wood products that store carbon.

Unfortunately, we have got about 80 million acres in need of treatment and need it now. The federal forests lag behind.

We need to pass legislation like the Resilient Federal Forests Act, which I have introduced with others to address this; and whether that is considered decarbonization or not it is the right kind of bipartisan policy to pursue and we can do it right here in America.

So let us talk about that as well and let us talk about the needs for our communities in the fossil-energy-rich cities and counties in Texas and Pennsylvania that have been pursuing the economic benefits fostered by the technological revolution in oil and natural gas production to the New England communities that do not have the energy infrastructure to ensure even heat and power on the coldest or hottest nights or warmest days.

So, let us talk about these policies too, in terms of what matters to people every day, and then together we should be able to find bipartisan solutions, moving forward, as we have in the past.

And with that, Mr. Chairman, I yield back the balance of my time.

[The prepared statement of Mr. Walden follows:]

PREPARED STATEMENT OF HON. GREG WALDEN

Yesterday, our Majority leadership held a press conference to outline their plans for decarbonizing the United States by 2050. And today we are reviewing some potential paths to achieve this goal.

What decarbonization really means for consumers and workers in terms of policy prescriptions remains to be seen, but we should look very carefully before we leap back into the failed regulatory approaches the Majority appears to be contemplating.

Republicans believe that prudent steps should be taken to reduce emissions and address current and future climate risks. These steps require we examine the costs, effectiveness, and economic impacts of solutions proposed to address these risks. And they require we do not undermine the economic priorities of communities and states around the nation.

For this reason, we have urged our Majority colleagues to avoid resurrecting top-down policies that have been shown to be costly and harmful to consumer and worker interests; and instead, work with Republicans on the bi-partisan policies we have been pursuing over the past several Congresses.

These policies aim to continue America's leadership role in developing innovative technologies to produce energy with little or no emissions.

And our record on this front is clear and positive for the climate. Republicans have been working with Democrats over the past several Congresses to remove regulatory barriers to new technological advances in power generation, from hydroelectric power to small modular nuclear, from carbon capture and storage incentives to power grid reforms.

Because innovation is where the long-term solutions to climate change are, we want America to lead the world in innovation, as we always have, especially on clean energy and environmental cleanup.

Instead of focusing solely on regulations that mandate emissions reductions here in the U.S., we need to put more emphasis on the parts of the world with some of the greatest CO2 emissions, like China and India.

Our most effective policies will be the ones that encourage and support development of clean energy technologies here in the U.S. by American workers, which then can be sold to those countries and around the world. These may not be the splashy promises—however unrealistic—that drive news coverage and they may not be the ones that are popular with the environmental lobby; but they are the ones that can have meaningful impact on global emissions while growing the U.S. economy and protecting the American worker.

This is why pursuit of policies like 45Q carbon sequestration tax credits enacted last Congress offer so much potential for cleaner fossil energy.

We will hear this morning about the promises carbon capture holds and what might be done to improve its prospects. And we know there is more innovation over the horizon.

We should talk about what it takes to ensure the United States can lead on clean fossil energy technology, on nuclear technology and not cede our dominance to our adversarial competitors globally. We already risk that in the nuclear technology space and we need to make sure that doesn't continue.

Closer to home, we have to pursue practical policies that strengthen local economies and make our communities safer.

In the Northwest, while we've benefited from clean hydropower, wind, geothermal and solar power, we've suffered greatly from the lack of management of our federal forest lands, which are burning up every summer, choking our citizens and polluting our atmosphere.

Actively managing our forests not only reduces the risk of fire, it also reduces carbon emissions. It promotes healthy younger stands of trees, maximizing our forest's ability to actively sequester carbon. All this while creating jobs and wood products that store carbon. Unfortunately, with around 80 million acres in need of treatment, our federal forests lag behind. We need to pass legislation—like the Resilient Federal Forests Act which I have introduced—to address this, and whether that is considered decarbonization or not, it is the right kind of bi-partisan policy to pursue.

Let's talk about that. And lets talk about the needs of other communities-from the fossil-energy-rich cities and counties in Texas and Pennsylvania that have been pursuing the economic benefits fostered by the technological revolution in oil and natural gas production to the New England communities that do not have the energy infrastructure to assure heat and power on the coldest nights or warmest days.

Let's talk about these policies in terms that matter to people every day. And find bi-partisan solutions that work for families and consumers.

Mr. TONKO. The gentleman yields back, and the Chair would like to remind Members that pursuant to committee rules all Members' written opening statement shall be made part of the record.

With that, I now introduce our witnesses for today's hearing.

We have Dr. Karl Hausker, senior fellow, climate program at the World Resources Institute. Next, we have Ms. Shannon Angielski, executive director of the Carbon Utilization Research Council.

Then Mr. Armond Cohen, executive director of the Clean Air Task Force. And finally, Dr. Cleetus, who is a policy—the policy director of Climate and Energy Program at the Union of Concerned Scientists.

Before we begin, I would like to explain the lighting system. In front of you are a series of lights. The light will initially be green at the start of your opening statement. The light will turn yellow when you have one minute remaining.

Please begin to wrap up your testimony at that point. The light will turn red when your time has expired. At this time, the Chair will now recognize Dr. Hausker for five minutes to provide his opening statement, welcome to you and all of our panelists, and thank you for your time and the intellect that you will share with us.

STATEMENTS OF KARL HAUSKER, Ph.D., SENIOR FELLOW, CLIMATE PROGRAM, WORLD RESOURCES INSTITUTE; SHANNON ANGIELSKI, EXECUTIVE DIRECTOR, CARBON UTILIZATION RESEARCH COUNCIL; ARMOND COHEN, EXECUTIVE DIRECTOR, CLEAN AIR TASK FORCE; AND RACHEL CLEETUS, Ph.D., POLICY DIRECTOR, CLIMATE AND ENERGY PROGRAM, UNION OF CONCERNED SCIENTISTS

STATEMENT OF MR. HAUSKER, Ph.D.

Dr. HAUSKER. Members of the committee, thank you for this opportunity to testify on America's clean energy future, and Chairman Tonko, Chairman Pallone, and colleagues, I really thank you for your leadership on launching a plan for developing climate legislation.

Let me focus on the four main takeaway messages in my testimony and I will refer to figures in that testimony as I go.

First, what does science tell us about emission pathways that can limit warming to 1.5 degrees? In Figure 1, you will see that global emissions need to reach net zero by mid-century and then actually turn negative. We need to achieve negative emissions later in the century.

Why negative? Because we are likely to overshoot safe concentrations of greenhouse gases that would keep us at 1.5 degrees. So we need sharp declines in emissions beginning in the 2020s and we will need, as you noted, major transformations in electricity generation, buildings, transport, and industry; then we will have to move to creating negative emissions through carbon dioxide removal. We can do that through natural means, planting trees and improving soil health, and we can also do it through technical means, and the two leading candidates are bioenergy plants with carbon capture and sequestration and the direct capture of CO2 from air, its concentration and safe storage underground.

We will likely need carbon dioxide removal at a large scale, up to 10 billion tons of CO2 per year by around mid-century, and this amount will exceed the capacity of those natural means and perhaps exceed what we can do with bioenergy with CCS.

And that is why I really want to emphasize that we are likely to need CCS with direct air capture by mid-century at the scale of billions of tons per year; and this leads me directly to my second major takeaway.

We must further develop CCS technology. Regardless of whether you think we need it on power plants, we will need it for that job of carbon dioxide removal.

Similarly, CCS will be needed for various industrial sources that have process emissions—iron, steel, chemicals, and cement. So we must take key steps in the coming decade. Improve the technology, scale up CCS, bring costs down, build pipelines and injection sites, refine our policy and governance frameworks, and build public acceptance. We can't wait until 2030 or 2040 to decide what to do on CCS.

My third takeaway—the transformations needed to get to net zero emissions are technologically feasible and affordable.

We can do it with current technology and near-commercial technology in the pipeline. But we should also innovate, as several of you have said, to keep being able to do it better and do it cheaper.

The strategies for transformation are depicted in Figure 2 in my testimony. It is quite simple at one level. First, be as energy efficient as possible across all sectors of the economy.

Second, electrification—switch everywhere possible from the direct combustion of fossil fuels to the direct use of electricity. Where you can't do that, develop the low-carbon zero-carbon fuels for those end uses.

Third, we are going to build a lot of electricity with zero carbon. That electrification process will make this a huge growth industry. So we will electrify the economy and then we need to go to zero-carbon generation.

And fourth, the fourth key strategy, of course, is carbon capture, which I just described.

Takeaway number four—my last takeaway—to produce all that carbon-free electricity, we can build out solar and wind very aggressively in the coming years. But we also need to commercialize—fully commercialize the other zero-carbon options.

So in Figure 3 in my testimony, I depict the great, wonderful jaw-dropping decrease in solar and wind costs over the last 10 years.

Many models suggest that we could move to 60, 70, 80, maybe even 90 percent renewable generation from solar and wind over the next decades, especially if we support it with transmission—expanded transmission, demand management, and storage.

However, most modelers and analysts understand that we need to complement any wind and solar with other dispatchable and firm power sources.

Sometimes you can do that with hydro and geothermal and bioenergy. But we are also likely to need carbon-free generation sources that aren't constrained by location like hydro and geothermal.

So the good news here is that companies like NetPower are developing CCS approaches to capture 100 percent of emissions from fossil fuel plants, and companies like NuScale are developing advanced nuclear options and small modular reactors that can play a role in America's clean energy future.

So my closing thought is that is risky to bet the climate on just a single set of technologies. Support RD&D across a broad set and let us keep our focus on carbon emissions, not on the market share of any particular technology.

I look forward to your questions. Thank you.

[The prepared statement of Dr. Hausker follows:]

TESTIMONY OF KARL HAUSKER, Ph.D.

SENIOR FELLOW, U.S. CLIMATE PROGRAM, WORLD RESOURCES INSTITUTE

U.S. HOUSE OF REPRESENTATIVES, ENERGY AND COMMERCE COMMITTEE

SUBCOMMITTEE ON ENVIRONMENT AND CLIMATE CHANGE

HEARING ON "BUILDING AMERICA'S CLEAN FUTURE: PATHWAYS TO DECARBONIZE THE ECONOMY"

JULY 24, 2019

My name is Karl Hausker, and I am a Senior Fellow in the U.S. Climate Program at the World Resources Institute (WRI). WRI is a nonprofit, non-partisan environmental think tank that goes beyond research to provide practical solutions to the world's most urgent environment and development challenges. We work in partnership with scientists, businesses, governments, and non-governmental organizations across the globe to provide information, tools and analysis to address problems like climate change, the degradation of ecosystems and their capacity to provide for human well-being. I also bring to the Committee my expertise as the Chief Economist of the Senate Energy and Natural Resources Committee (1987-1992), Deputy Assistant Administrator of EPA's Policy Office (1993-1995), and many years of consulting to Federal and state governments in the areas of climate change and energy policy.

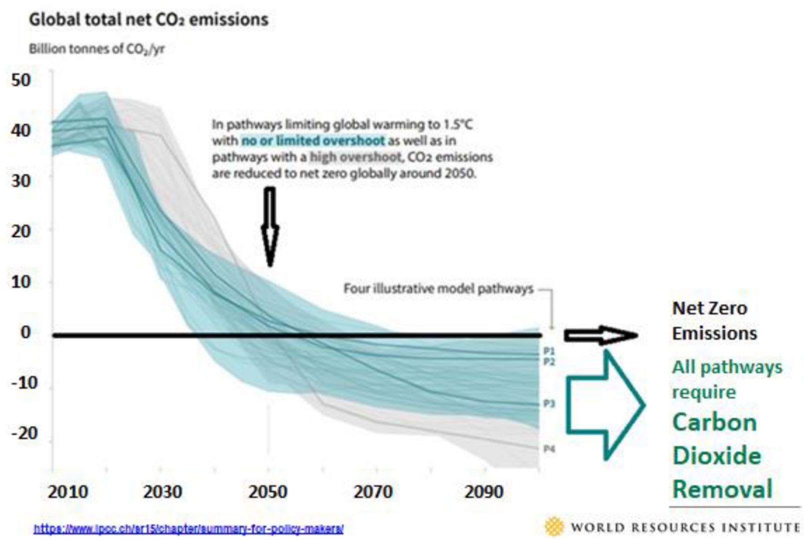
I thank the Committee for the opportunity to testify on America's Clean Energy Future. In addition to this written testimony, I have attached a presentation I gave to Chairman Tonko and the Sustainable Energy and Environment Coalition last February that expands on some of the themes in my testimony.

The evidence that climate change is underway grows stronger every year, along with the evidence that it is largely attributable to human activities. Climate change is already damaging human health, our economic well-being, our national security, and the ecosystems that underpin our food production and water supplies. Climate change is contributing to the destruction of countless plant and animal species. It is a problem that calls for U.S. action and for U.S. leadership in technology innovation and in diplomacy (because it requires collective action by nations).

To avoid the worst effects of climate change, the United States, and the world as a whole, must dramatically reduce greenhouse gas (GHG) emissions over the next 30 years. I'm going to focus on CO2 in my testimony, which drives roughly 80 percent of global warming, but we should not lose sight of the need to reduce the other greenhouse gases, such as methane, nitrous oxide, and certain industrial gases.

The Intergovernmental Panel on Climate Change (IPCC) issued a report last year that laid out various emission pathways that could limit average global warming to 1.5 degrees Celsius. Figure 1 presents the IPCC pathways, with global emissions of CO2 in billions of tons on the vertical axis, and years from present out to 2100 on the horizontal axis. Of the many model projections examined, the IPCC has indicated 4 "illustrative pathways" (P1, P2, P3, P4) as representative of the broader range of pathways.

Figure 1. IPCC Pathways Limiting Warming to 1.5 Degrees



There are two key takeaways from the IPCC pathways:

1. **Net-Zero By Mid Century.** Global emission reductions must begin a sharp descent in the coming decade. Major transformations will be required across the economy: in electricity generation, buildings, transport, and industry. CO2 emissions should reach net-zero by roughly 2050, i.e., our gross emissions minus CO2 removed from the atmosphere by natural means and technical means.
2. **Carbon Dioxide Removal After Mid Century**. The IPCC pathways indicate a very strong likelihood that we will overshoot GHG concentrations limits consistent with 1.5 degrees warming, and that we will need to begin removing up to 10 billion tons of CO2 from the atmosphere each year. Some of this can be done by natural means (e.g., planting trees and improving soil health) but it is also highly likely to require technical means (e.g., bioenergy power plants with carbon capture and storage (BECCS) and/or direct air capture and storage of CO2 (DACS).[1]

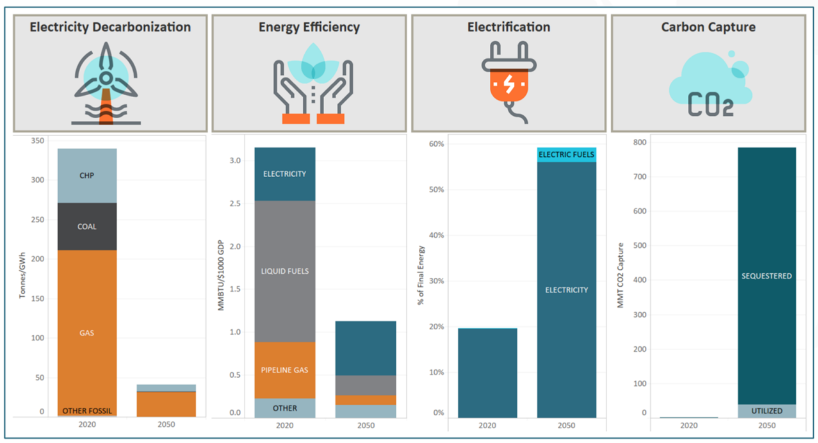
This has an important implication for the further development of carbon capture and storage (CCS) technology: regardless of whether one believes that CCS technology will be needed for electricity

[1] See WRI's working papers on these topics: CarbonShot: Creating Options for Carbon Removal at Scale in the United States. Available at: https://www.wri.org/publication-series/carbonshot-creating-options-carbon-removal-scale-united-states

generation, the technology is very likely to be needed for the job of carbon dioxide removal. Similarly, CCS is very likely to be needed to reduce process emissions from certain industrial sources (e.g. cement, iron and steel, chemicals and refining).

These transformations across all sectors in how we use energy will be challenging in many ways, but the transformations are technologically feasible and affordable. There are four basic strategies for achieving a clean energy future. These strategies are quite consistent across IPCC studies and other studies of how to achieve a clean energy economy. Figure 2 is from a recent US study conducted as part of the Deep Decarbonization Pathways Project.

Figure 2. Four Strategies for a Clean Energy Future.



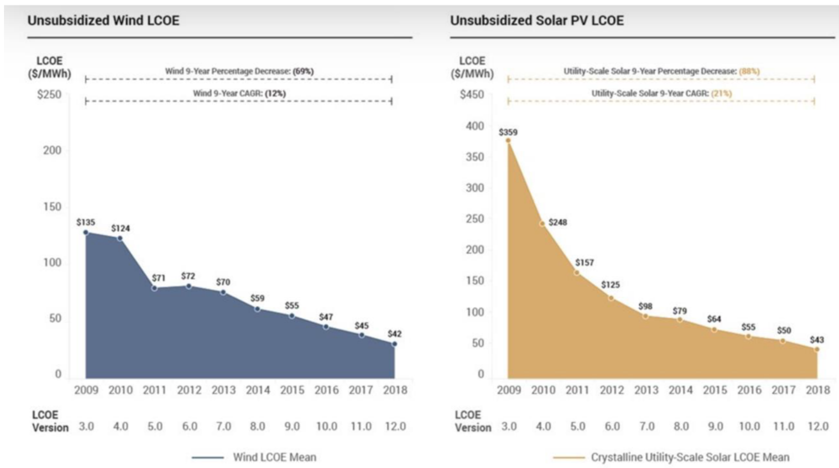
Source: Evolved Energy Research, *350 ppm Pathways for the United States,* 2019.
https://www.evolved.energy/single-post/2019/05/08/350-ppm-Pathways-for-the-United-States

The four strategies are:

- **Energy efficiency**: aggressive improvements in across all sectors.
- **Electrification** of end-uses across all sectors, wherever feasible, and adoption of zero- or near zero-carbon fuels in certain end-uses.
- **Clean generation of electricity** from zero-carbon or near zero-carbon sources.
- **Carbon capture and storage** (from power plants, industrial operations, and/or direct air capture facilities), along with some utilization of CO2 capture in production processes.

There are encouraging signs of progress related to all of these strategies: the success of LED light bulbs, the growing market for electric vehicles, the potential for low-emission cement production, just to name a few. However, the most significant development of the past decade has been the jaw-dropping reductions in the cost of renewable electricity generation (see Figure 3). Through a combination of public and private R&D, supportive policies, and achievement of economies of scale, wind and solar photovoltaic (PV) costs have decreased dramatically over the last decade as measured by the metric of the "Levelized Cost of Energy" (LCOE). The LCOE per MWh decreased by nearly 70% for wind and by nearly 90% for utility-scale solar PV (Lazard 2018). With these decreases, wind and utility-scale solar PV are now the least expensive sources of new generation in many parts of the U.S. Customer demand for renewable or "green" electricity can now be met at a fraction of the cost ten years ago.

Figure 3. Recent Cost Decreases in Wind and Solar PV Electricity Generation (LCOE)



Source: Lazard, *Levelized Cost of Energy and Levelized Cost of Storage 2018,* November 8, 2018
https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/

These cost reductions for wind and solar PV lead most analysts to project that renewables will become the largest source of electricity as we transition to clean energy. For example, in the IPCC pathways, renewables grow to represent roughly 60 to 80 percent of total generation globally by 2050, with most the remainder generated by hydro power, nuclear power, and fossil or bioenergy with CCS. Most of the modeling of clean energy pathways for the US shows similar high market shares for renewables by 2050. However, there are important caveats to the LCOE metric – one cannot conclude simplistically that wind and solar PV are "cheapest", period, end of story. Power system dynamics are much more complex.

There are some calls for 100% renewable electricity (or even 100% renewable sources for all energy), and there are a few modeling studies that suggest this would be feasible. But power systems that become highly dependent on solar and wind ("variable renewables") would be likely to face reliability and affordability challenges when their share of the total generation mix crosses certain thresholds.[2]

[2] Variable (or "intermittent") renewables (wind and solar) present more challenges than other renewables such as hydro power, geothermal, or bioenergy that can operate in baseload and/or load-following modes. However, the quantity of wind and solar generation can be scaled up dramatically to reduce CO2 emissions, in contrast to other renewables that face constraints on their expansion (e.g., suitable locations, competition for food production and preservation of biodiversity).

The level of that threshold can be modeled, but when and how it actually might be crossed in the years and decades ahead is impossible to predict with certainty. It will depend on many factors that affect the "integration costs" of variable renewables:

- the resource mix of the particular power system;
- the degree to which transmission expansion can enable aggregation of diverse resources across large geographic areas; and
- the roles demand response, load-shifting, and storage technologies can ultimately play.

These integration costs are likely to escalate as the share of solar PV and wind increases, and that is why one cannot simply conclude they are "cheapest" based on LCOE, and that we should commit to a 100% renewable grid.

The good news is that, in the U.S., we can build out solar PV and wind aggressively for many years to come, make operational changes as variable generation increases, and reliably manage our power systems. At the same time, we should strive to fully commercialize other near zero-carbon technologies. The good news here is that NetPower and other companies are developing promising approaches to CCS that capture nearly 100% of CO_2 emissions from fossil plants. In addition, NuScale and other companies are developing small modular reactors and other designs that may allow new nuclear power plants to play a role in America's clean energy future.

Our strategies for limiting global warming should be resilient in the face of the many ways that various zero-carbon technologies could develop.

- Technical and economic feasibility could change over time (e.g., with R&D and scale-up in production)
- Various political and institutional factors could change over time (e.g., the political acceptability of large-scale renewables deployment, nuclear power, CCS technologies and infrastructure, and large-scale transmission expansion)

Leading states, such as California, New York, Nevada, and Washington, appear to be setting policies in a resilient and pragmatic way. They are boosting their Renewable Portfolio Standards to 50 or 60 percent in the mid-term (e.g., 2030 or 2035). However, in setting long-term goals, they are taking a technology-neutral approach, calling for zero carbon or net-zero carbon energy systems.

It's risky to "bet the climate" on any single set of technologies. The United States should greatly expand its zero-carbon generation now with low-cost wind and solar, while aggressively investing in research, development, and demonstration of a broad portfolio of zero-carbon electricity options, given the many uncertainties related to the evolution of any single technology. Let's keep our focus on the problem – carbon emissions -- not the market share of any particular technology.[3]

[3] See also: Woolard, John. 2019. "Beyond Renewables: How to Reduce Energy-Related Emissions by Measuring What Matters." WRI Commentary. https://www.wri.org/news/beyond-renewables-how-reduce-energy-related-emissions-measuring-what-matters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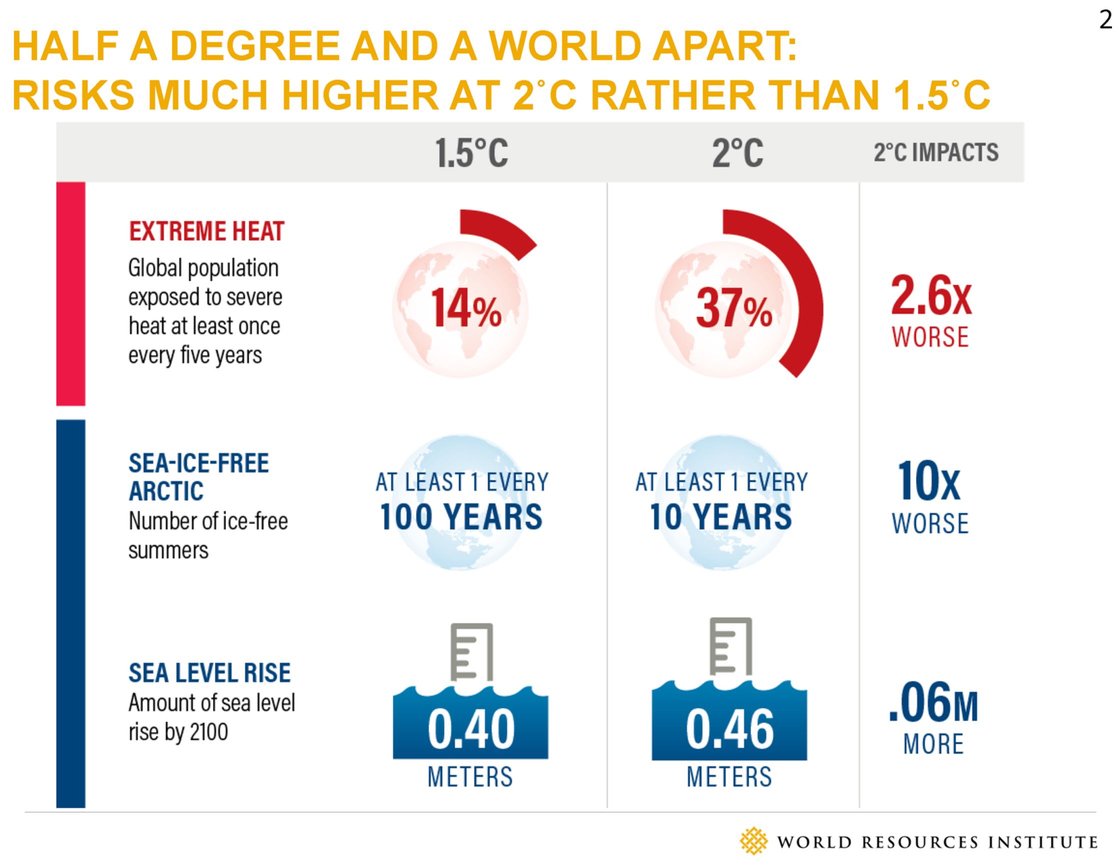
INSTITUTE
PATHWAYS TO A SAFE CLIMATE
DAN LASHOF, PH.D.
DIRECTOR, WRI-U.S.
KARL HAUSKER, PH.D.
SENIOR FELLOW
FEBRUARY 2019
Briefing for the Sustainable Energy and Environment Coalition


2
HALF A DEGREE AND A WORLD APART:
RISKS MUCH HIGHER AT 2˚C RATHER THAN 1.5˚C
1.5°C
2°C
2°C IMPACTS
EXTREME HEAT
Global population exposed to severe heat at least once every five years
14%
37%
2.6x
WORSE
SEA-ICE-FREE ARCTIC
Number of ice-free summers
AT LEAST 1 EVERY
100 YEARS
AT LEAST 1 EVERY
10 YEARS
10x
WORSE
SEA LEVEL RISE
Amount of sea level rise by 2100
0.40
METERS
0.46
METERS
.06M
MORE
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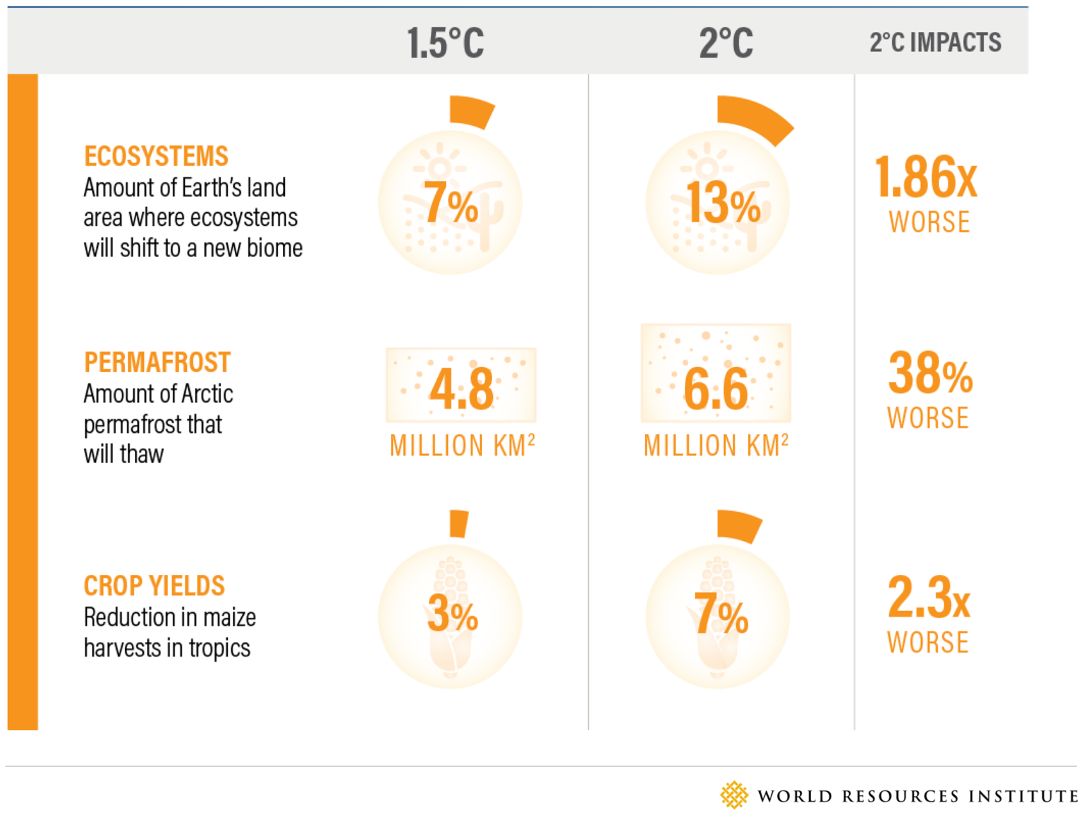
1.5°C
2°C
2°C IMPACTS
ECOSYSTEMS
Amount of Earth's land area where ecosystems will shift to a new biome
7%
13%
1.86x WORSE
PERMAFROST
Amount of Arctic permafrost that will thaw
4.8 MILLION KM²
6.6 MILLION KM²
38% WORSE
CROP YIELDS
Reduction in maize harvests in tropics
3%
7%
2.3x WORSE
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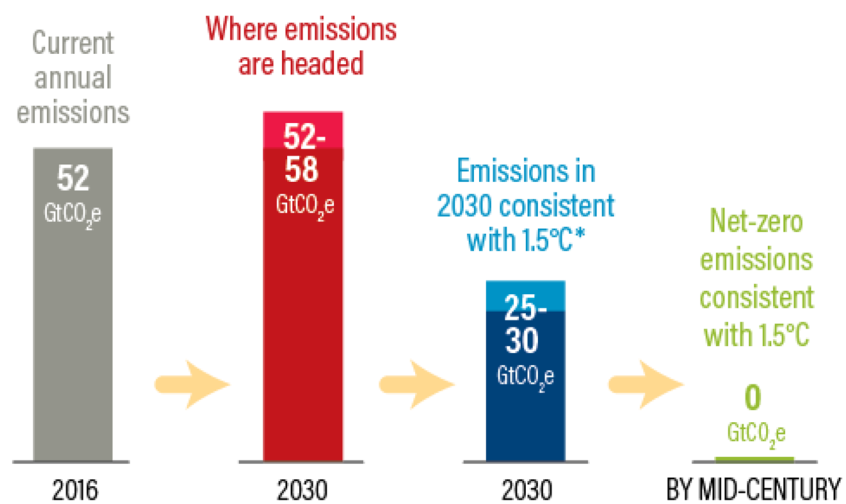
LIMITING WARMING TO 1.5ºC REQUIRES MAJOR AND IMMEDIATE TRANSFORMATION

The World Is Not on Track to Limit Temperature Rise to 1.5°C



Notes: *on average, no or low overshoot.

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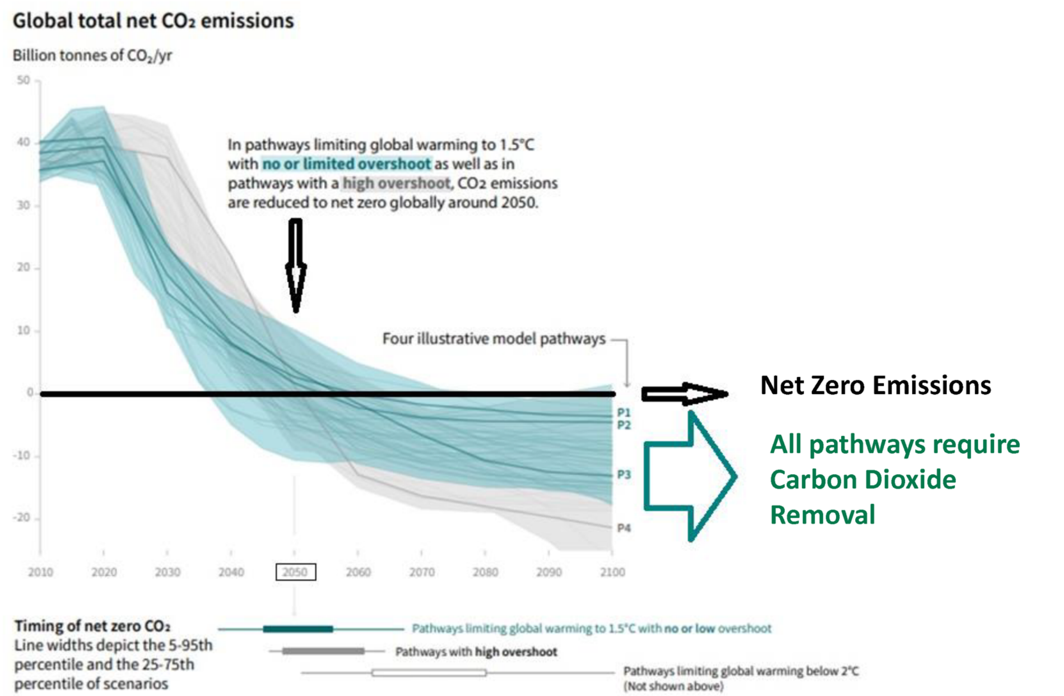
1.5ºC PATHWAYS REQUIRE NET-ZERO BY MID-CENTURY



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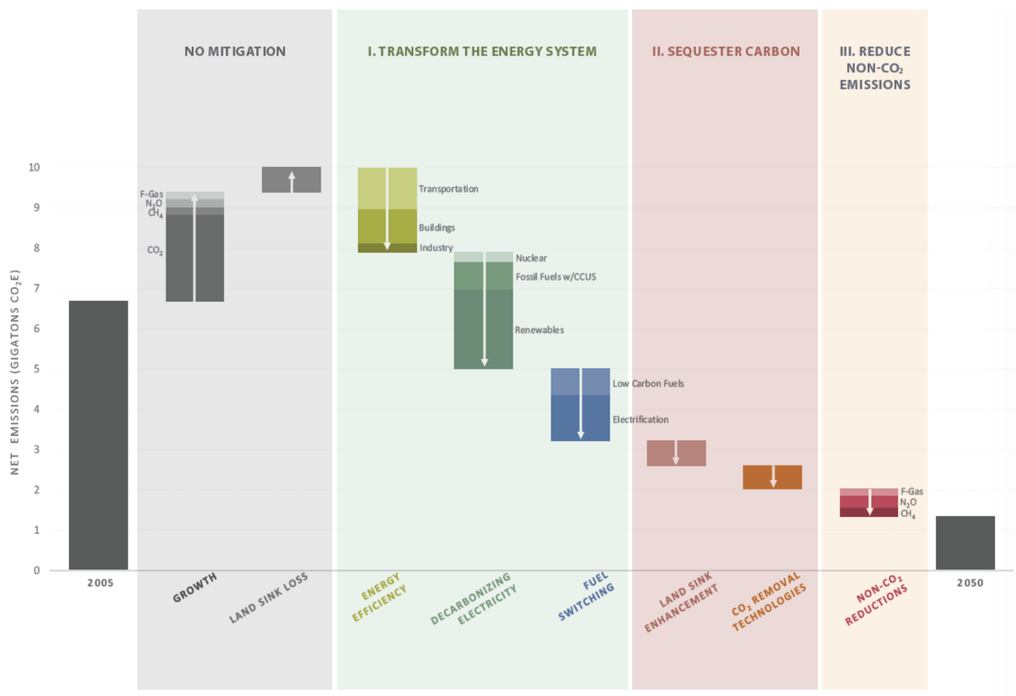
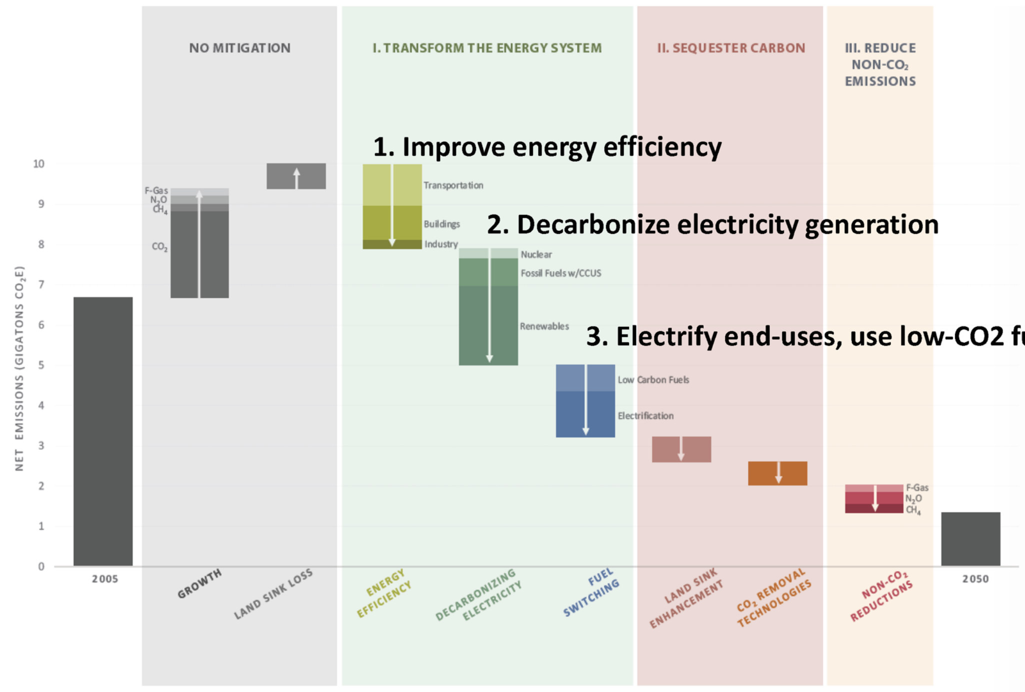
U.S. MID-CENTURY STRATEGY REPORT



Source: *United States Mid Century Strategy for Deep Decarbonization*, November 2016

U.S. MID CENTURY STRATEGY REPORT



Source: ***United States Mid Century Strategy for Deep Decarbonization*****, November 2016**

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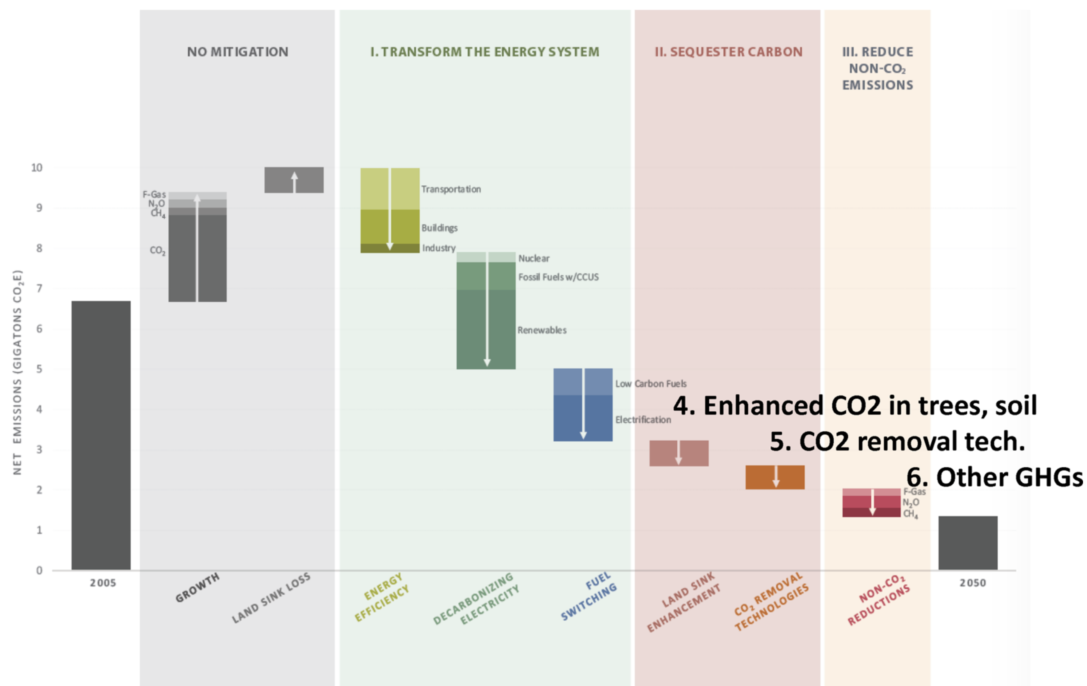
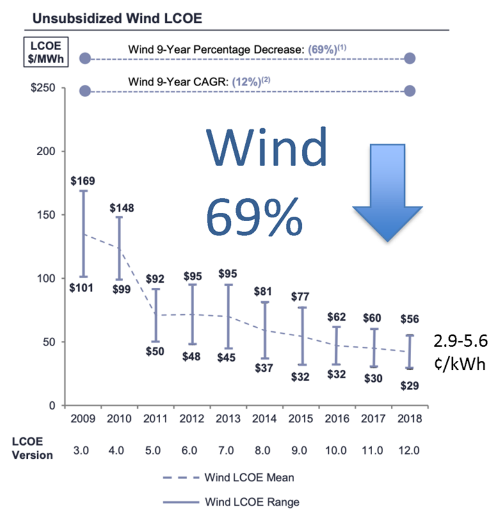
U.S. MID CENTURY STRATEGY REPORT

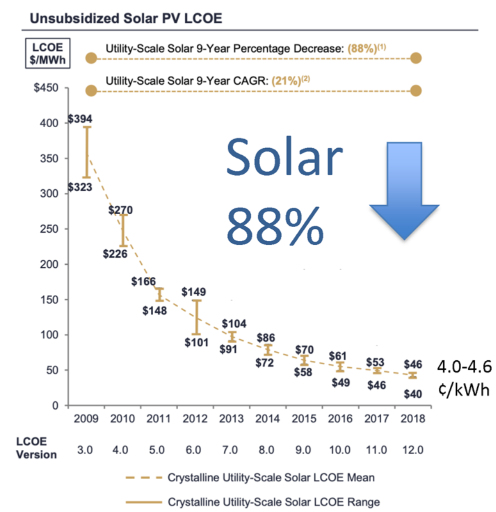


Source: *United States Mid Century Strategy for Deep Decarbonization*, November 2016

RENEWABLES REVOLUTION

Dramatic cost decreases in wind and solar PV over the past 10 years
Wind: 3 – 6 cents/kWh. Solar PV: 4 – 5 cents/kWh (Utility-Scale).





LAZARD

Source: Lazard estimates.
(1) Represents the average percentage decrease of the high end and low end of the LCOE range.
(2) Represents the average compounded annual rate of decline of the high end and low end of the LCOE range.

8

Lazard's LCOE Analysis, v.12.0, Nov. 2018,
https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/

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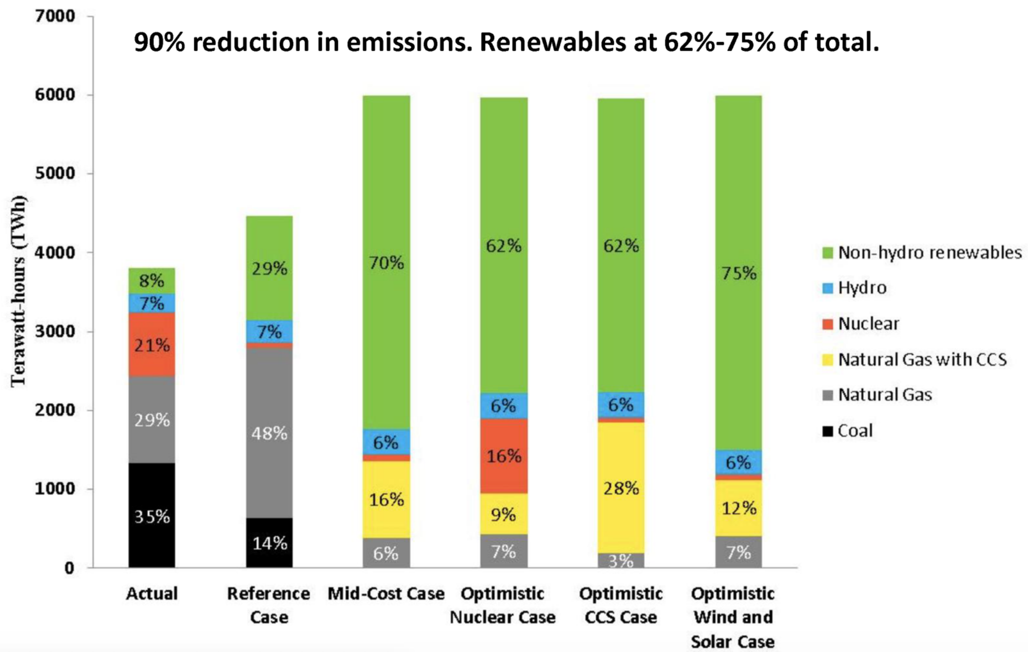
EXAMPLES OF FEDERAL AND STATE GOALS: 100% RENEWABLE AND 100% CLEAN

	100% Renewable	100% Clean
Federal	• **By 2035**: Climate Solutions Act, H.R. 330, Rep. Lieu, 2019. • **By 2035**: OFF Act, H.R. 3671, Rep. Gabbard, 2017.	• **By 2030:** AOC-Markey GND Resolution, 2019. • **By 2050**: 100 By '50 Act, S.987 Sen. Merkley, 2017.
State	• **By 2045**: Hawaii, H.B. 623 (enacted), 2015. • **By 2040**: Colorado, Governor's proposal for 100% renewable electricity	• **By 2045**: California S.B.100 (enacted), 2018. • **By 2040**: New York, Governor's Green New Deal proposal, 2019 • **By 2050:** New Jersey, Governor's E.O. #28 on Energy Master Plan • **By 2050:** Campaign commitments from governors in WA, CT, IL, ME, MI, WI

EXAMPLE OF ELECTRICITY GENERATION MIX: FOUR SCENARIOS, UNION OF CONCERNED SCIENTISTS



Cleetus et al., US Power Sector in a Net Zero World, 2016

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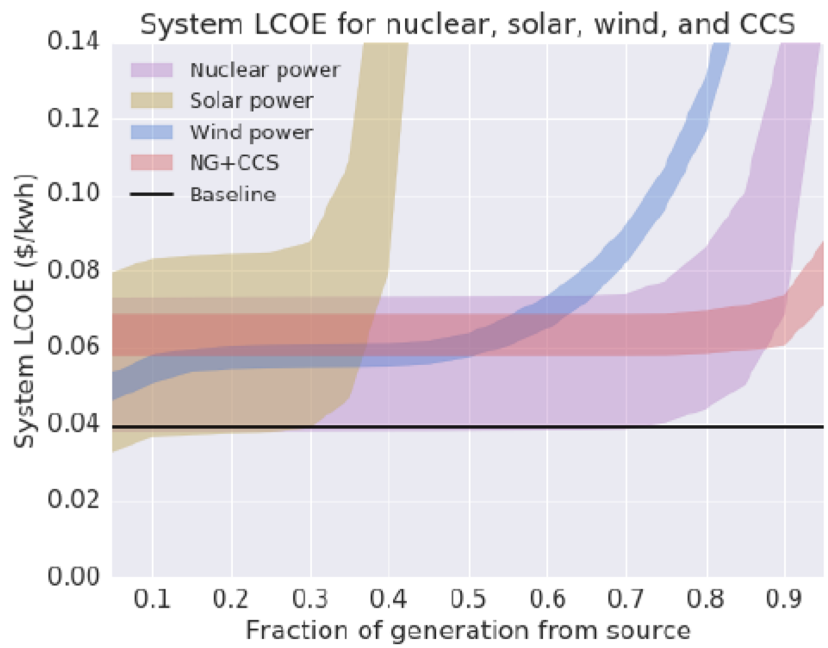
THE RIDDLE OF "CHEAP RENEWABLES" AND "HIGH SYSTEM COSTS"



Platt et al, Analyzing Energy Technologies and Policies Using DOSCOE, 2017.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3015424

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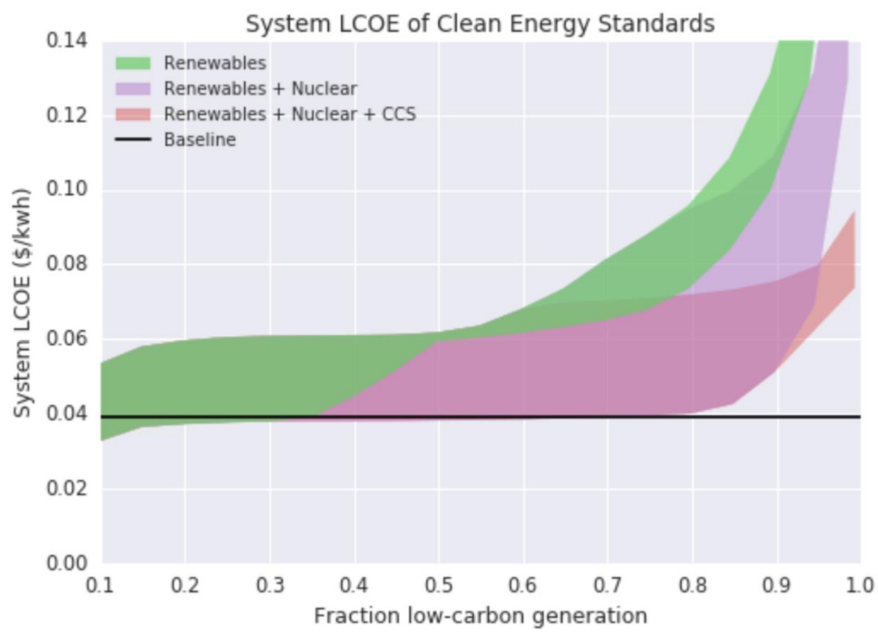
TOTAL SYSTEM COSTS MINIMIZED BY DIVERSE PORTFOLIO



Platt et al, Analyzing Energy Technologies and Policies Using DOSCOE, 2017.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3015424

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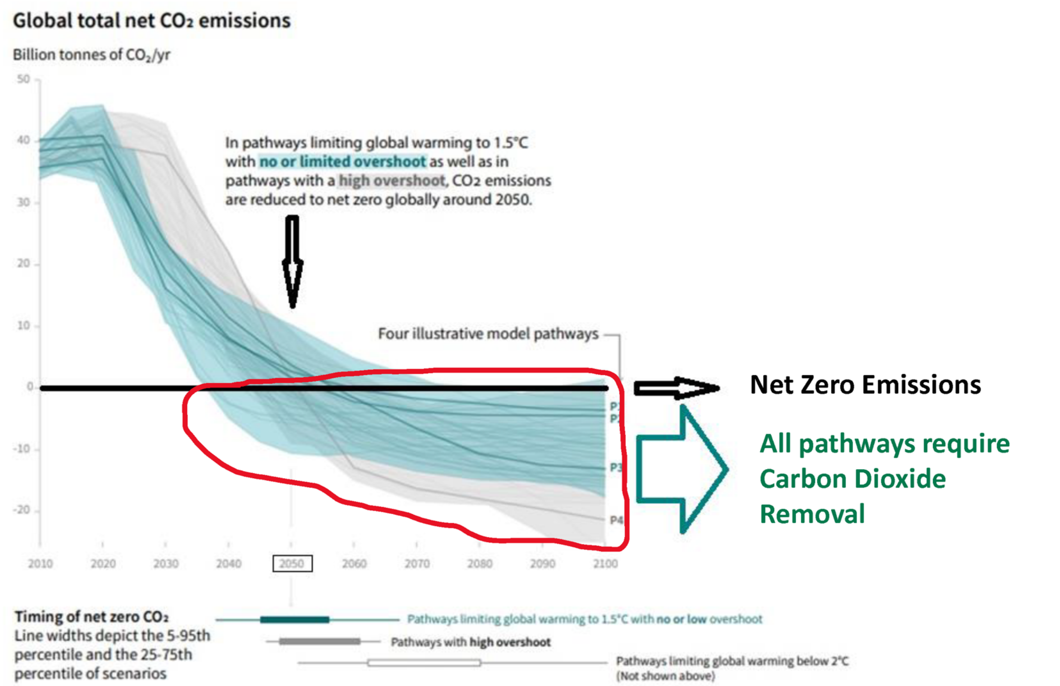
WHAT ARE OUR OPTIONS FOR CARBON DIOXIDE REMOVAL AT LARGE SCALE (BILLIONS OF TONS/YEAR)



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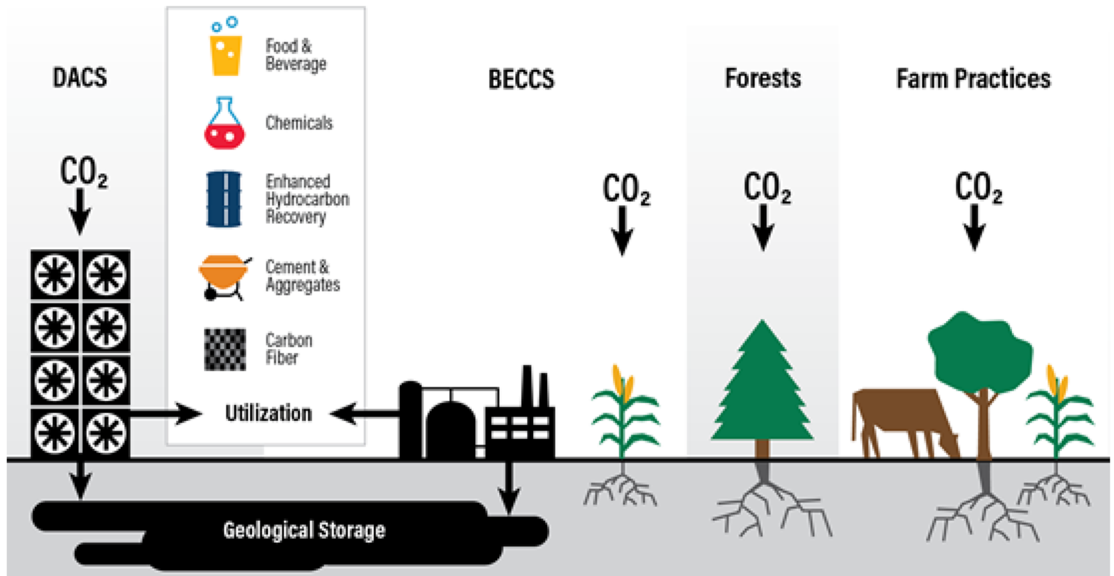
CARBON DIOXIDE REMOVAL OPTIONS



Also at research stage: Enhanced weathering of rocks/minerals, and seawater capture

NEAR-TERM CARBON DIOXIDE REMOVAL POLICY NEEDS

- Federal cross-cutting RD&D program
- Federal & state deployment-support policies
- Cross-cutting enabling investments in infrastructure and data systems

KEY TAKEAWAYS

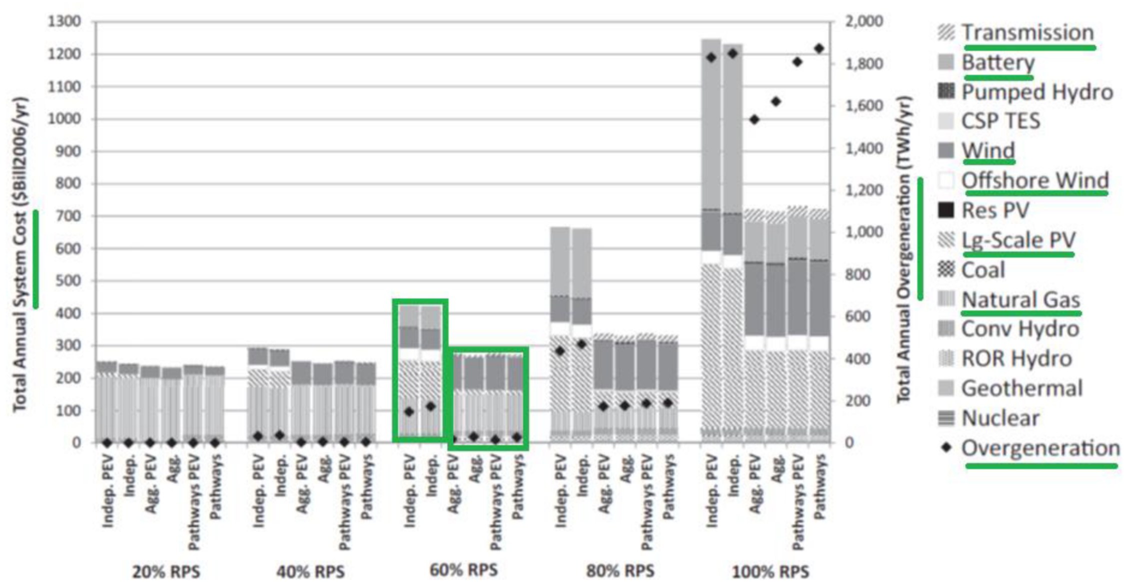
- Damages increase sharply if warming goes from 1.5 to 2 degrees C (and beyond)
- Need to achieve zero net emissions by midcentury to limit warming to 1.5ºC
- Broad technology portfolio can significantly cut cost to decarbonize electricity generation.
- Fully developing carbon dioxide removal approaches preserves pathways to 1.5ºC

ADDITIONAL SLIDES

EXAMPLE OF INTERPLAY OF TRANSMISSION, LOAD-SHIFTING, AND STORAGE IN HIGH RE PATHWAYS

- Study by NREL researcher
- Modeled RPS of 20/40/60/80/100%
- Modeled 6 pathways with variations related to transmission expansion, growth in plug-in electric vehicles (PEVs), and a path dependent feature.
  - Two pathways labeled “Indep.” always had similar results, and assumed the current transmission system
  - The other four pathways always had similar results.
  - Estimated least cost mix, system costs, and “overgeneration”

IMPACTS OF 20%-100% RENEWABLES



Frew et al, Flexibility mechanisms and pathways to a highly renewable US electricity future , 2016. https://web.stanford.edu/group/efmh/jacobson/Articles/Others/16-Frew-Energy.pdf

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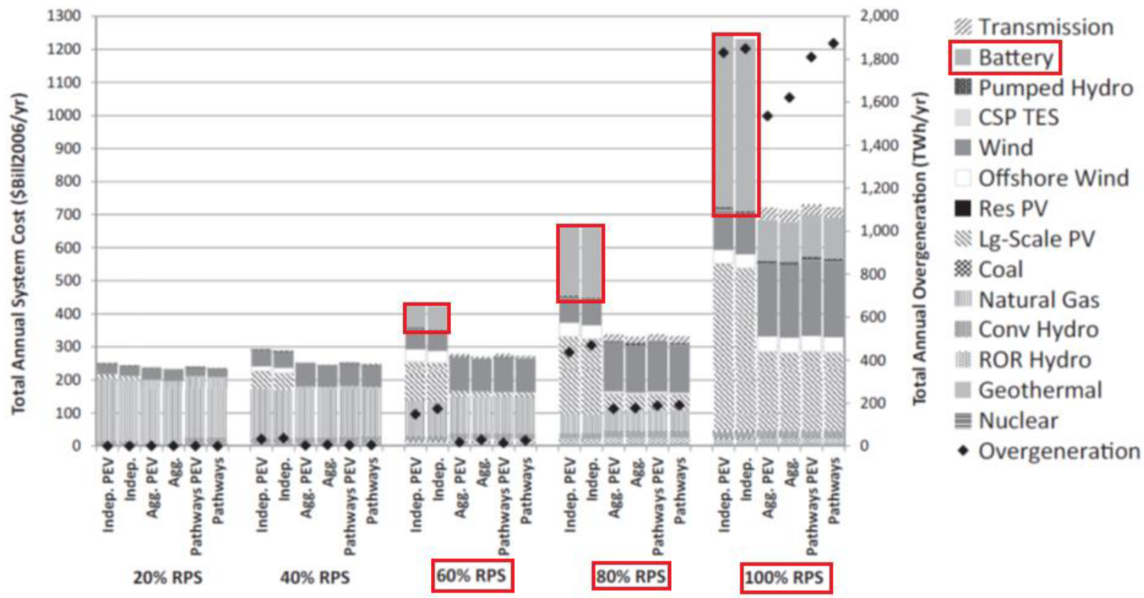
IMPACTS OF 20%-100% RENEWABLES

- With current transmission system, costs and overgeneration escalate sharply as system reaches 60/80/100% renewables.
- Storage costs drive up cost (batteries). Total system costs increase 4x.



https://web.stanford.edu/group/efmh/jacobson/Articles/Others/16-Frew-Energy.pdf

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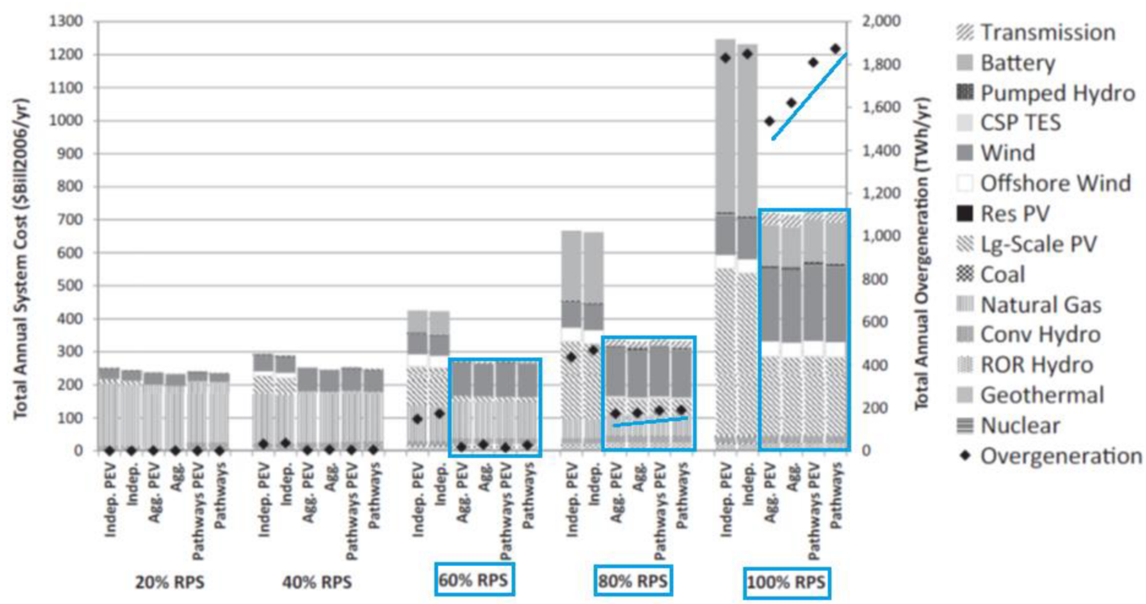
IMPACTS OF 20%-100% RENEWABLES

- With expanded transmission system, costs and overgen are roughly stable up to 60-80%, and then at 100%, system cost more than doubles and overgen. increases



https://web.stanford.edu/group/efmh/jacobson/Articles/Others/16-Frew-Energy.pdf

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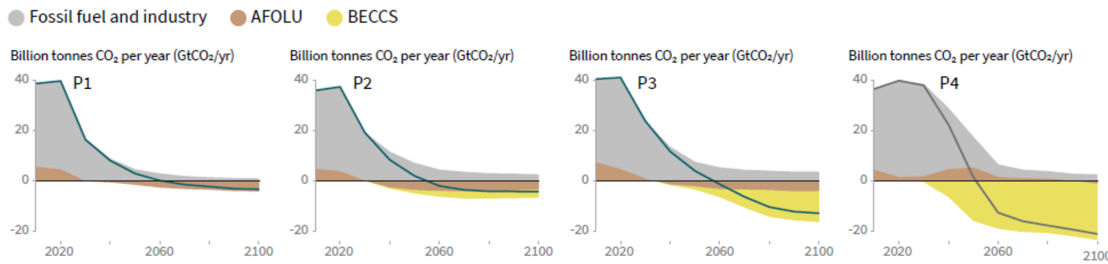
FOUR ILLUSTRATIVE PATHWAYS – CO2

- **Major transformations needed in power, buildings, transport, industry**
- **Carbon dioxide removal (CDR) needed via afforestation, BECCS, and/or other technologies and processes**

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



P1: A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

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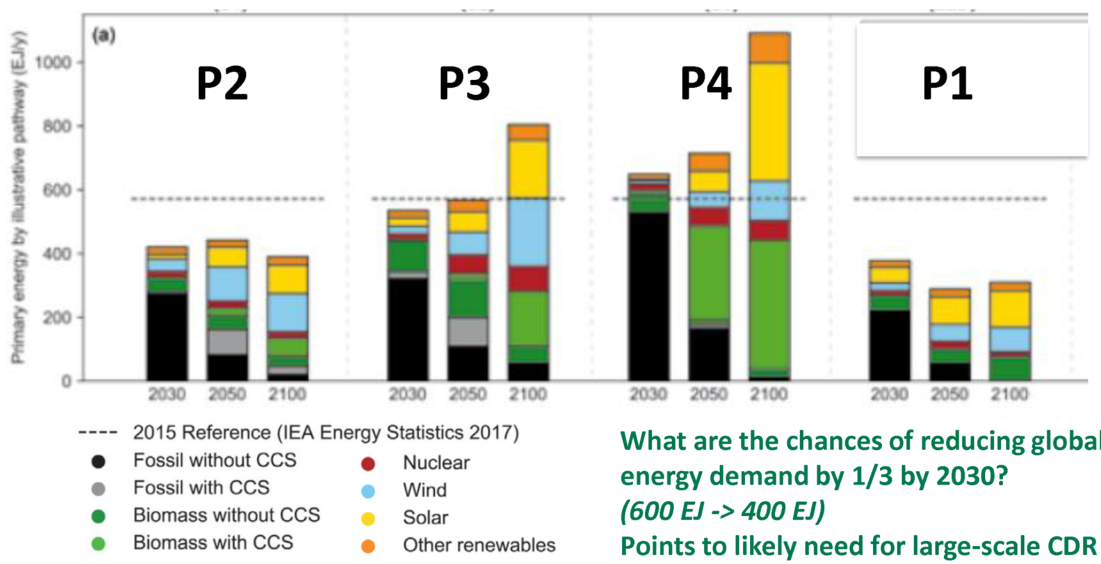
IPCC FOUR PATHWAYS: PRIMARY ENERGY SUPPLY

Renewables grow exponentially. CCS and nuclear play key roles.
P1 and P2: primary energy <u>decreases</u> from ~600 EJ/yr to ~400 EJ/yr by 2030
P3: <u>slight decrease</u> by 2030; back to ~600 EJ/yr by 2050.
P4: <u>slow growth</u> through 2050



What are the chances of reducing global energy demand by 1/3 by 2030?
(600 EJ -> 400 EJ)
Points to likely need for large-scale CDR

https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf Fig. 2.16

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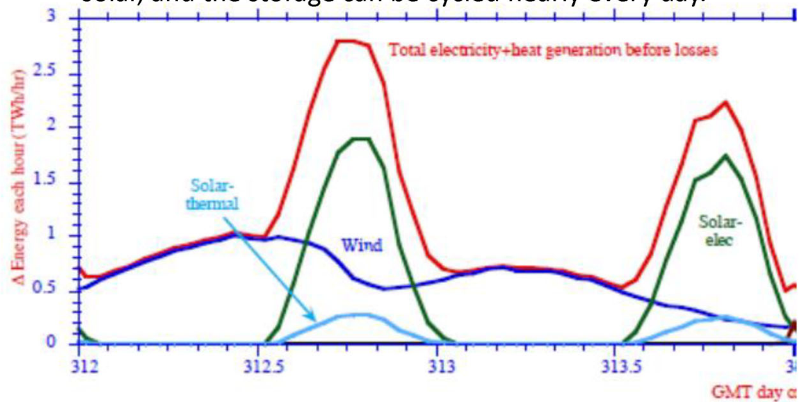
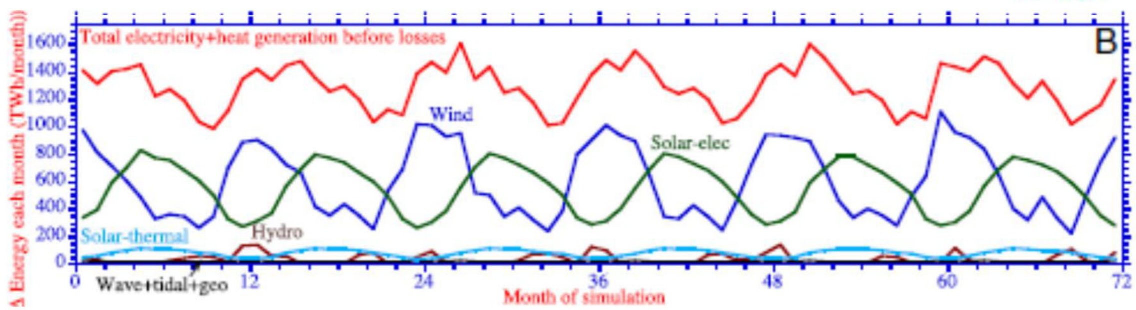
VARIABLE OUTPUT: DAILY, SEASONAL, AND "UH-OH'S"…

"dunkelflaute"
dark doldrums

Storage of 12 hours of load can balance daily variation in solar, and the storage can be cycled nearly every day.





Jacobson et al., Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes, 2015. https://www.pnas.org/content/112/49/15060

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Mr. TONKO. Thank you, Dr. Hausker.

And next, we will here from Ms. Angielski. You are recognized for five minutes, please.

STATEMENT OF MS. ANGIELSKI

Ms. ANGIELSKI. Thank you, Chairman Tonko and Ranking Member Shimkus, for the invitation to testify before the subcommittee today and to discuss initiatives that can decarbonize the U.S. economy, and we really appreciate your leadership on these issues.

I just want to start by introducing the Carbon Utilization Research Council. CURC is an industry coalition focused on technology solutions for the responsible use of our fossil energy resources in a balanced low-carbon generation portfolio.

Members of CURC believe that American fossil fuel ingenuity and technology innovation will satisfy the world's growing appetite for affordable energy, improve energy security, increase exports of U.S. resources and manufactured energy equipment, create high-paying jobs, and improve environmental quality.

In order to achieve these objectives, members of CURC are at the forefront of their industries to develop and commercialize technologies that will transform the way the world uses fossil fuels.

My testimony will address five key points describing what is needed to unlock the innovation that is needed to decarbonize the use of fossil fuels in the power sector.

Point one—the growing use of fossil fuels must be accompanied by robust investment in carbon capture utilization and storage, or CCUS.

This is because global fossil fuel use is projected to rise well into the future. As a result, modelling conducted by the Intergovernmental Panel on Climate Change and the International Energy Agency, or the IEA, agree that carbon capture is an integral part of the technology solution set in order to cost effectively achieve global climate targets.

A recent IEA analysis shows that high capture rates are wind combined with sustainable biofuels. Power generated from fossil fuels can achieve net zero carbon emissions.

Other recent analysis from IEA estimates that by 2060 CCUS accounts for approximately 100 gigatons of the CO2 emissions reductions needed to meet the global goals of the two degrees scenario.

To put this scale of emissions reductions into perspective, this would be the same as, roughly, 1,100 coal units installing carbon capture by 2030 and storing CO2 from those systems for the next 30 years.

This would also be the same as 3,200 natural gas combined cycle units with the same amount of carbon capture over the same period.

Modelling also shows that in order to achieve deep decarbonization goals, CCUS must be complemented with technology such as direct air capture and other negative emissions technologies.

To date, however, carbon capture has not been deployed at the rate needed to achieve deep decarbonization objectives.

Point two, U.S. industry, thankfully, has years of experience with CCUS. Projects operating in the U.S. today capture, roughly, 25 million metric tons of CO2 annually from industrial processes.

Large volumes of CO2 are also transported through a 4,500-mile pipeline network and some of that CO2 is stored in well-documented and studied geologic reservoirs across the country.

For more CCUS deployment to occur, projects need to integrate each of these individual elements together into one system. The Petra Nova project that retrofit a coal power plant with carbon capture in Texas and transports that CO2 by a pipeline into a nearby oil field as well as the Archer Daniels Midland ethanol production facility with carbon capture in Illinois are just two prime examples of how to integrate those different industries together into one process and demonstrate that CCUS is technically feasible.

Point three—while carbon capture is in the early stages of deployment, the U.S. is making significant strides to reduce costs and create a robust carbon capture industry. Innovative research and development is well underway that will further improve the cost and performance of new carbon capture technologies through DOE's world class carbon capture and storage programs.

These technologies have the promise of providing dispatchable fossil fuel power generation with low to zero carbon emissions necessary to support the growth of renewables and achieve decarbonization of the power grid.

Importantly, carbon capture is fuel and emissions agnostic. This means investment in power sector applications will also benefit the use of carbon capture in other industries and when applied to other fuel gas streams.

With improved technology and deployment, the technology will follow a well understood cost reduction curve and economies of scale will be achieved in the same way this happened with the wind and solar industries.

Four, investments in carbon capture will benefit the environment, improve energy security, and provide macroeconomic benefits to the U.S. economy.

Analysis connected by CURC and ClearPath Foundation shows that there are significant economic benefits to the U.S. if the public-private sector investments in carbon capture are undertaken.

Our analysis projects that at least 17 gigawatts and up to 87 gigawatts of market-driven carbon capture paired with enhanced solar recovery will significantly increase oil production, lower retail electricity rates, all of which contribute to substantial increases in annual GDP as well as create over 800,000 new jobs by 2040.

Five, with robust and sustained policy support, carbon capture can contribute to any deep decarbonization goals. 45Q is a key policy tool for catalyzing a carbon capture industry in this country and is seen as a model policy by international energy entities.

And while several carbon capture projects are in development as a result of this policy, project developers are eagerly awaiting issuance of Treasury guidance to understand how to use the tax credits.

However, even as the U.S. continues to invest in innovative research and projects that will be incentivized through the use of these credits, it is important to recognize that multiple policy tools will be needed to accelerate and attract investment in carbon capture.

I just want to mention several—there are several CCUS bills in Congress pending that would do that, some of which are before this committee, and I just want to recognize Congressman Peters and Mr. McKinley on the Utilizing Significant Emissions Act as well as the Carbon Capture Modernization Act are just two examples.

So in closing, I just want to close by saying the world is watching as we embark on these initiatives. Investment in CCUS will transform carbon dioxide into an economic resource, lower the cost of reducing emissions, save consumers money, and safeguard the environment.

Thank you.

[The prepared statement of Ms. Angielski follows:]

Testimony of Shannon Angielski

Executive Director

Carbon Utilization Research Council (CURC)

Before the

Committee on Energy & Commerce

Subcommittee on Environment and Climate Change

Hearing on "Building America's Clean Energy Future: Pathways to Decarbonize the Economy"

CURC Testimony:

"Contribution of Fossil Fuel Technology Innovation to Deep Decarbonization Objectives"

Washington, D.C.

July 24, 2019

EXECUTIVE SUMMARY OF CURC TESTIMONY: KEY POINTS

CURC is an industry coalition focused on technology solutions for the responsible use of our fossil energy resources in a balanced, low carbon generation portfolio. CURC's members include electric utilities and power generators that rely upon diverse sources for their electricity production, including natural gas and coal, and that own their own natural gas distribution companies, equipment manufacturers and technology innovators, national associations that represent the power generating industry, labor unions, coal producers, and state, university and technology research organizations. Members of CURC believe that American fossil fuels and ingenuity in technology innovation will satisfy the world's growing appetite for affordable energy, improve energy security, improve trade by increasing exports of U.S. resources and manufactured energy equipment, create high-paying jobs, and improve environmental quality. In order to meet these important objectives, members of CURC are at the forefront of their industries and partnering with the Department of Energy to develop and commercialize technologies that will transform how the world uses fossil fuels. Successfully achieving these objectives will require a robust and sustained set of policies to incentivize the development and deployment of low and zero-carbon fossil energy technologies that are necessary to achieve global climate targets and that can also contribute to a robust U.S. economy.

On behalf of CURC, I am pleased to testify before the House Energy & Commerce Committee, Subcommittee on the Environment and Climate Change, to discuss efforts to decarbonize the U.S. economy. Given the nature of CURC and our mission, my testimony will focus on technology innovation efforts to decarbonize the use of fossil fuels in the power sector, particularly with respect to carbon capture, utilization and storage, and how those efforts can be leveraged with other industrial uses of fossil fuels. Throughout my testimony, please note that I refer to carbon capture, utilization and storage as either "CCUS" or carbon capture, and carbon dioxide as carbon or CO_2.

I will address five key points in my oral testimony, and will reserve broader discussion on these points in my written testimony:

(1) The growing use of fossil fuels must be accompanied by robust innovation in carbon capture, utilization and storage in the production and use of fossil fuels in order to meet deep, de-carbonization objectives.
(2) Fortunately, the U.S. knows how to capture carbon, use it to produce valuable products, and store it in an abundance of well documented and studied geologic reservoirs.
(3) While carbon capture is in the early stages of deployment today, the U.S. is making significant strides to reduce costs and create a robust carbon capture industry.
(4) Investments in carbon capture will benefit the environment, improve energy security, and provide macroeconomic benefits to the U.S. economy.
(5) Carbon capture is bipartisan and industry agnostic. With robust and sustained policy support, carbon capture can contribute to any deep decarbonization goals.

The growing use of fossil fuels must be accompanied by robust innovation in carbon capture, utilization and storage in the production and use of fossil fuels. Global fossil fuel use is on the rise is projected to rise well into the future due to the important role fossil fuels play in providing affordable, reliable and low-cost energy. All modeling that has been conducted by international authorities, including the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA), agree that carbon capture, utilization and storage is an integral part of the technology solution set in order to cost-effectively achieve global climate targets. Recent analysis from IEA estimates that by 2060, CCUS accounts for approximately 100 gigatons of CO_2 emissions reductions to meet the goals of the 2°C scenario. [1] To put this scale of emissions reductions into perspective, this would be the same as roughly 1,100 coal units (500 MW in size) or 3,200 natural gas combined cycle units (500 MW in size) – or some combination of the two – installing CO_2 capture systems by 2030 and operating those systems for the next 30 years.[2] To date, CCUS has not been deployed at the rate needed to achieve this, which means CCUS development and deployment must be accelerated to meet any domestic or global deep decarbonization objectives.

At high capture rates, and/or when combined with sustainable biofuels, power generated from fossil fuels can achieve net zero carbon emissions, which is important to the broader discussion of achieving deep decarbonization from dispatchable grid technologies. Modeling also shows that in order to achieve deep decarbonization goals, CCUS must be complimented with technologies such as direct air capture and negative emissions technologies.

Fortunately, the U.S. knows how to capture carbon, use it to produce valuable products, and store it in an abundance of well documented and studied geologic reservoirs. Projects already operating in the U.S. capture roughly 25 million metric tons of CO_2 annually from industrial processes,[3] transport large volumes of CO_2 via a 4,500 mile pipeline network and store it in a variety of geologies across the country – in fact, companies have been doing this for nearly 50 years to enhance oil recovery, and for about 15 years in partnership with the U.S. Department of Energy (DOE) in other geologies like saline aquifers. In order to deploy more CCUS projects and increase the volume of captured CO_2, projects need to integrate all of those elements all together into one system. The PetraNova project that retrofit a coal power plant with carbon capture in Texas, and the Archer Daniels Midland ethanol production facility with carbon capture project in Illinois, are but two prime examples of how to integrate those different industry processes together into one project and demonstrate that carbon capture, utilization and storage is technically feasible.

While carbon capture is in the early stages of deployment today, the U.S. is making significant strides to reduce costs and create a robust carbon capture industry. The reason why there are not more CCUS projects operating is because each project is associated with higher costs, despite carbon capture being a relatively cost-competitive way to reduce emissions in many industries today. Thankfully innovative research and development is well underway that will further improve the cost and performance of new carbon capture technologies through the DOE's world class carbon capture and storage programs. These technologies have the promise of providing dispatchable fossil fuel power generation with low- to

[1] CCUS in the global energy context, presentation by Samantha McCulloch, Head of CCUS, International Energy Agency, 25th March 2019, http://www.curc.net/webfiles/Briefing%20Series/Briefing%20%231/McCulloch%20-%2028%20March%20CCUS%20Briefing.pdf

[2] This calculation assumes the coal plant operates at 75% capacity factor, the natural gas combined cycle plant at 60% capacity factor, and each with a 90% capture rate.

[3] "Global Status of CCS", 2018, Global CCS Institute

zero-carbon emissions necessary to support the growth of renewables and achieve deep decarbonization of the power grid. These novel power cycles are designed to facilitate the capture of CO_2 at a lower energy penalty and cost than conventional methods. There are also advances in post-combustion carbon capture - which can be retrofit to the world's existing infrastructure, much of which is relatively young - that can lower the cost of capture. If this technology innovation is coupled with robust and sustained deployment policies, the technology will follow a well understood cost reduction curve and economies of scale will be achieved in the same way this happened with the wind and solar industries. Importantly, carbon capture is fuel and emissions agnostic; the technology can capture CO_2 molecules emitted from oil, coal and natural gas combustion, as well as from other sources such as ethanol production and even from the air. Investments in power sector applications of carbon capture will also benefit the use of these technologies in other industries and when applied to other fuel gas streams because the fundamental science is generally the same, regardless of the source of CO_2. This technology has broad applications and with leveraged and targeted investments, can have a significant economic and environmental impact.

Investments in carbon capture will benefit the environment, improve energy security, and provide macroeconomic benefits to the U.S. economy. Analysis conducted by CURC and ClearPath Foundation shows that under a wide range of scenarios, there are significant economic benefits to the U.S. if public-private sector investments in carbon capture are undertaken under a wide range of scenarios. Our analysis projects at least 17 GW and up to 87 GW of market-driven carbon capture deployment paired with enhanced oil recovery by 2040, resulting in a significant increase in domestic oil production and lower cost retail electricity rates, all of which contribute to substantial increases in annual GDP as well as over 800,000 new jobs through 2040. These macroeconomic benefits are described in more detail in my written testimony.

Carbon capture is bipartisan and industry agnostic. With robust and sustained policy support, carbon capture can contribute to any deep decarbonization goals. Enactment of the reformed 45Q carbon sequestration tax credits is one measure of bipartisan support; a broad number of industries can implement carbon capture with the 45Q credits. 45Q is a key policy tool for catalyzing a carbon capture industry in this country and is seen as a model policy by international energy entities. This policy will lower the cost of implementing carbon capture by providing a tax credit for every metric ton of CO_2 that is captured from any qualified industrial processes and stored in geologic reservoirs including oil reservoirs, or when the CO_2 is converted into other products like chemicals or used in cement production. Several carbon capture projects are in development as a result of this policy. Project developers are eagerly awaiting issuance of Treasury guidance to understand how to be eligible for the tax credits in order for investments to flow into projects and meet the commence construction deadline to claim the 45Q tax credits. For the record, there are concerns that project developers are already up against the statutory commence construction deadline, and to ensure this tax credit can be used in the way it was intended by Congress, it will be necessary to extend that deadline.

Even as the U.S. continues to invest in the public-private partnership for research, development and demonstration of carbon capture, and in projects that will be incentivized from the 45Q tax credits, it is important to recognize that additional policy tools will help to accelerate and attract investment in carbon capture projects in the same way Congress enacted several policy tools that resulted in the commercialization of other nascent energy technologies.

Several bills have been introduced that would put into place these policies and help to reduce the costs of implementing carbon capture in some industries. Some of those include:

- the "Utilizing Significant Emissions with Innovative Technologies" or "USE IT" Act (S. 383 / H.R. 1166), which would invest in carbon utilization and direct air capture research as well as streamline carbon capture and CO_2 pipeline infrastructure to help catalyze a CCUS industry;
- the "Carbon Capture Modernization Act" (S. 407 and H.R. 1796) which would modify the tax credit requirements to unlock nearly $2 billion in existing investment tax credits for carbon capture retrofits in the power sector;
- new authorizations to update the federal RD&D funding programs for carbon capture for fossil fuel power generation and for industrial capture through the "Fossil Energy Research and Development Act" (H.R. 3607) and the "Enhancing Fossil Fuel Energy Carbon Technology" or "EFFECT" Act (S. 1201); and
- two bills that would make carbon capture projects eligible for master limited partnerships (the "Financing Our Future Energy Act", (S. 1841 / H.R. 3249)), and private activity bonds (the "Carbon Capture Improvement Act" (S. 1763)) which are designed to lower the cost of financing of carbon capture projects.

These are just some examples of the bills before Congress with bipartisan support that would complement the existing 45Q tax credit program. CURC welcomes the opportunity to work with this Committee in the evaluation of these policies and in the design of other policies that may be within the jurisdiction of this Committee to incentivize the development and deployment of carbon capture technology.

Conclusion. I want to close by saying the world is watching as we embark on these initiatives. U.S. investment in clean energy technologies, including those for coal, has resulted in the development and deployment of technologies that are in use all over the world today. Federal investments in all forms of clean energy have been a major return on the investment for both the U.S. economy and the global environment. As the U.S. continues to invest in carbon capture, we will benefit not only from cleaner power that is necessary to meet any deep decarbonization objectives, but also from new markets for U.S. technologies both domestically and abroad. Investment in CCUS technology will transform carbon dioxide into an economic resource, lower the cost of reducing emissions, create jobs, save consumers money, safeguard the environment, and demonstrate that the technology can be used here as well as around the world.

INTRODUCTION AND BACKGROUND

CURC is an industry coalition focused on technology solutions for the responsible use of our fossil energy resources in a balanced, low carbon generation portfolio. CURC's members include electric utilities and power generators that rely upon diverse sources for their electricity production, including natural gas and coal, and that own their own natural gas distribution companies, equipment manufacturers and technology innovators, national associations that represent the power generating industry, labor unions, coal producers, and state, university and technology research organizations. Members of CURC believe that American fossil fuels and ingenuity in technology innovation will satisfy the world's growing appetite for affordable energy, improve energy security, improve trade through increasing exports of U.S. resources and manufactured energy equipment, create high-paying jobs, and improve environmental quality. In order to meet these important objectives, members of CURC are at the forefront of their industries and partnering with the Department of Energy to develop and commercialize technologies that will transform the way the world uses fossil fuels. Successfully achieving these objectives will require a robust and sustained set of policies to incentivize the development and deployment of low and zero-carbon fossil energy technologies that are necessary to achieve global climate targets and that can also contribute to a robust U.S. economy.

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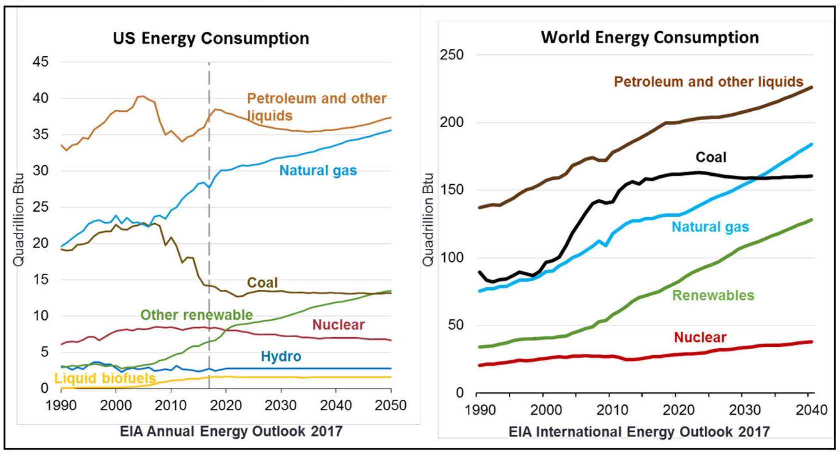
CURC's testimony will address five key points:

(1) The growing use of fossil fuels must be accompanied by robust innovation in carbon capture, utilization and storage in the production and use of fossil fuels in order to meet deep, de-carbonization objectives.
(2) Fortunately, the U.S. knows how to capture carbon, use it to produce valuable products, and store it in an abundance of well documented and studied geologic reservoirs.
(3) While carbon capture is in the early stages of deployment today, the U.S. is making significant strides to reduce costs and create a robust carbon capture industry.
(4) Investments in carbon capture will benefit the environment, improve energy security, and provide macroeconomic benefits to the U.S. economy.
(5) Carbon capture is bipartisan and industry agnostic. With robust and sustained policy support, carbon capture can contribute to any deep, decarbonization goals.

(1) THE GROWING USE OF FOSSIL FUELS MUST BE ACCOMPANIED BY ROBUST INNOVATION IN CARBON CAPTURE, UTILIZATION AND STORAGE IN THE PRODUCTION AND USE OF FOSSIL FUELS.

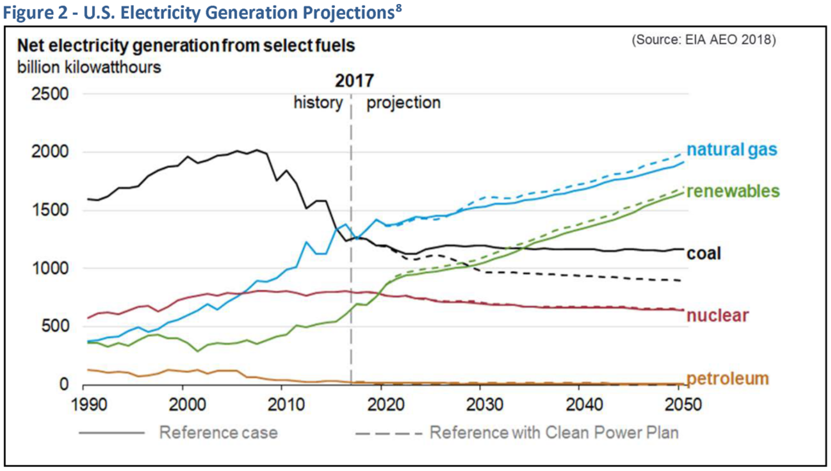
Domestically, fossil fuels comprised 80% of total U.S. energy consumption[4] and 63.5% of net electricity generation[5] in 2018. The U.S. Energy Information Administration (EIA) estimates that coal and natural gas will provide 58% of total U.S. net electricity generation in 2040[6] (see Figures 1 and 2). Globally, consumption of coal and natural gas are projected to provide 45% of energy consumption in 2030 and will grow to nearly 50% of global consumption by 2040 (see Figure 1).

Figure 1 - U.S. and World Energy Consumption[7]



[4] EIA Today in Energy, April 16, 2019. https://www.eia.gov/todayinenergy/detail.php?id=39092
[5] EIA FAQ, Updated March 1, 2019. https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
[6] EIA 2019 Annual Energy Outlook. https://www.eia.gov/outlooks/aeo/pdf/appa.pdf
[7] EIA Annual Energy Outlook 2017, EIA International Energy Outlook 2017.

Figure 2 - U.S. Electricity Generation Projections[8]



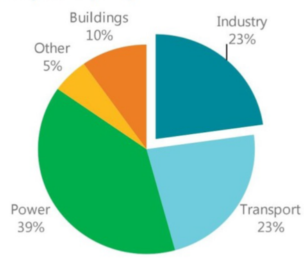
While the U.S. EIA projects coal consumption will decline, EIA also projects it will still stabilize and continue to represent a major portion of electricity generation through 2050. That decline is offset by increased use of natural gas. Similarly, the International Energy Agency (IEA) projects global coal consumption will continue to increase before stabilizing, but global coal consumption does not decrease through 2050. Globally, oil and natural gas consumption will increase to more than double their consumption rates today. All of these fuels are projected to increase in use because they are widely available in emerging countries and economies, low cost, and abundant. No matter whether using coal, oil or natural gas, each fuel source significantly contributes to global energy and economic growth, and emits CO_2 without the use of carbon capture abatement technologies.

[8] U.S. EIA Annual Energy Outlook 2018.

As shown in Figure 3, the point sources attributable to those emissions come from electricity and steam production, cement, iron and steel, biofuels and biopower production, and other industrial sources. These industries are critical for economic growth and stability, and to support a growing global population, and cannot simply be eliminated. While some of these industrial processes can be electrified, many (e.g. steel production, some chemicals production, etc.) require the use of fossil fuels. This is because the energy demand for these industry sectors is high-temperature heat, for which there are few alternatives to the direct use of fossil fuels. And while some industries can be electrified, some cannot. In addition, dispatchable fossil power generation with CCUS will still be needed to provide a source of electricity. The good news is that carbon capture technology can help reduce and even eliminate the emissions of CO_2 from those sources.

Figure 3 – Global CO_2 Emissions from Different Economic Sectors[9]

Figure 3. Direct CO_2 emissions by sector, 2017



Source: IEA (2019).

In order to meet deep decarbonization objectives, technologies must be developed and deployed to reduce the carbon footprint from the growing use of fossil fuels. Several international models, including the United Nations International Panel on Climate Change (UNIPCC) and the IEA, show the need for CCUS technology to significantly reduce CO_2 emissions in order to meet global climate targets (see Figure 4).

[9] Transforming Industry through CCUS, May 2019, International Energy Agency

Figure 4 - Importance of Technology in Meeting Global Climate Targets

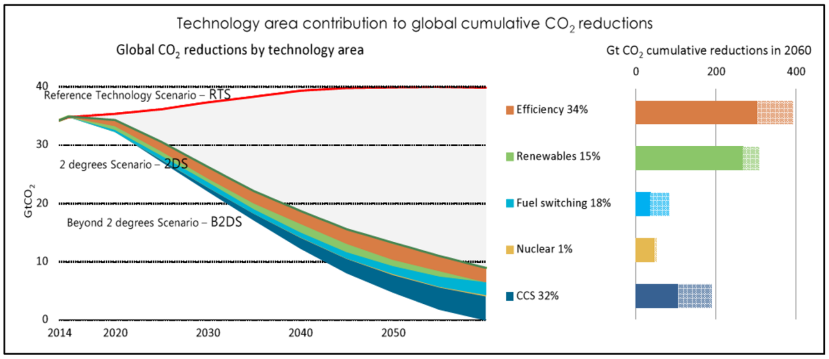


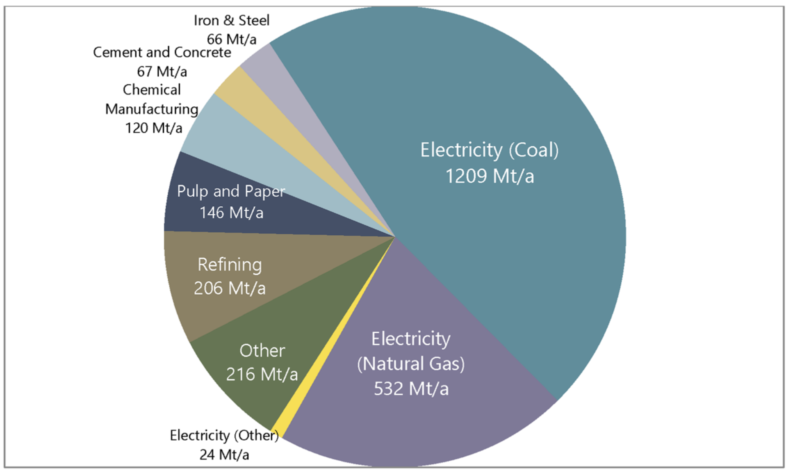
Figure 4 from IEA shows the critical role that CCUS plays with increasing climate ambition.[10] By 2060, CCUS accounts for approximately 100 gigatons of CO_2 emissions reductions necessary to meet the goals of the 2°C scenario. To put this scale of emissions reductions into perspective, this would be the same as roughly 1,100 coal units (500 MW in size) or 3,200 natural gas combined cycle units (500 MW in size) – or some combination of the two – installing CO_2 capture systems by 2030 and operating those systems for the next 30 years.[11] To date, CCUS has not been deployed at the rate needed to achieve either of these targets, which means CCUS development and deployment must be accelerated to meet any domestic or global deep decarbonization objectives.

At higher capture rates and/or when combined with sustainable biofuels, power generated from fossil fuels can achieve net zero carbon emissions, which is important to the broader discussion of achieving deep decarbonization from dispatchable grid technologies.[12] Modeling also shows that in order to achieve deep decarbonization goals, CCUS must be complimented with technologies such as direct air capture and negative emissions technologies.

[10] CCUS in the global energy context, presentation by Samantha McCulloch, Head of CCUS, International Energy Agency, 25th March 2019, http://www.curc.net/webfiles/Briefing%20Series/Briefing%20%231/McCulloch%20-%2028%20March%20CCUS%20Briefing.pdf
[11] This calculation assumes the coal plant operates at 75% capacity factor, the natural gas combined cycle plant operates at a 60% capacity factor, and each has a 90% capture rate.
[12] Towards Zero Emissions in Power Plants Using Higher Capture Rates or Biomass, IEA GHG Technical Report 2019-02, March 2019, IEA Greenhouse Gas R&D Programme.

Nearly 75% of U.S. of point source CO_2 emissions are from electric power sector. In 2017, approximately 2.6 Gigatons of CO_2 were reported to the U.S. Environmental Protection Agency (EPA) as being emitted from industrial point sources in the U.S. Figure 5 shows the breakdown of CO_2 emissions reported to the EPA Greenhouse Gas Reporting Program in 2017. The U.S. electric power sector is where the most significant reductions can occur.

Figure 5 - U.S. CO_2 Emissions by Sector (2017)[13]

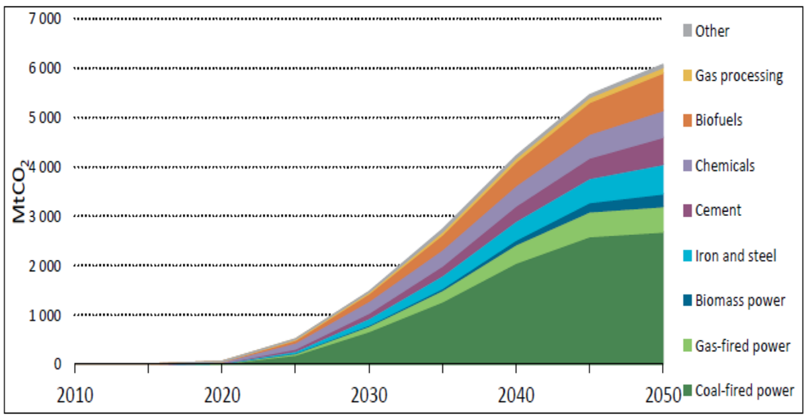


IEA estimates that the power sector accounts for approximately 39% of global CO_2 emissions, so the impact of carbon capture in reducing emissions from the power sector will be significant (see Figure 3 above).

[13] U.S. EPA GHGRP 2017 data by point sources (https://www.epa.gov/ghgreporting)

Globally, the IEA projects that a significant amount of carbon capture deployment will be needed for natural gas and coal power generation in order to achieve global climate targets (see Figure 6), contributing to nearly 50% of the CO_2 emissions reductions from carbon capture across industry sectors. This is largely driven by increasing coal use mostly for power generation in Asia and China, where the coal fleet is very young and continues to grow.[14]

Figure 6 - Global Carbon Capture by Industry to Achieve 2° Scenario[15]

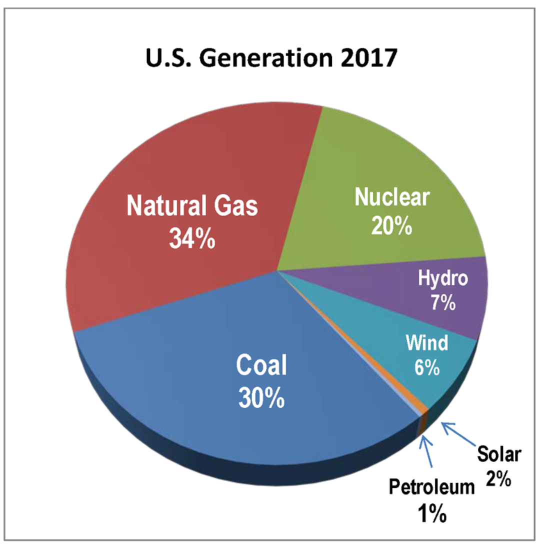


Source: Derived from *Energy Technology Perspectives 2016 (IEA, 2016)*.

[14] CCUS in the global energy context, presentation by Samantha McCulloch, Head of CCUS, International Energy Agency, 25th March 2019, http://www.curc.net/webfiles/Briefing%20Series/Briefing%20%231/McCulloch%20-%2028%20March%20CCUS%20Briefing.pdf
[15] International Technology Perspectives 2016, IEA.

In order to achieve deep decarbonization on the power grid, dispatchable fossil fuel power generation with carbon capture will be necessary to ensure a balanced, cost-effective, and reliable electric generation portfolio. Today coal and nuclear together provide 50% of our electricity and represent over 60% of total installed generating capacity (See Figure 7). Low cost natural gas has resulted in some natural gas combined cycle (NGCC) systems transitioning to baseload operation, whereas historically, due to higher gas prices, those units were load following due to their ability to readily ramp up and down in response to changes in power demand. In addition to NGCC becoming more widespread, federal and state financial incentives and policies have helped the deployment of renewables that, with a number of deployments, have come down in market price. As the existing coal fleet is on average, 45 years of age, it will be important to invest in low- and zero-carbon fossil generating technologies that can provide low cost, dispatchable power to ensure a balanced generating portfolio can be sustained and provide benefits in the future. A balanced generating portfolio will help to avoid prices spikes in fuel costs, mitigate against weather impacts, balance the intermittency of wind and solar resources, and protect consumers from higher electricity costs.

Figure 7 - U.S. Generation 2017[16]



[16] U.S. EIA Annual Energy Outlook, 2018

(2) FORTUNATELY, THE U.S. KNOWS HOW TO CAPTURE CARBON, USE IT TO PRODUCE VALUABLE PRODUCTS, AND STORE IT IN AN ABUNDANCE OF WELL DOCUMENTED AND STUDIED GEOLOGIC RESERVOIRS.

The U.S. already captures CO_2 from a variety of industrial processes. For example, CO_2 is separated and captured in the oil refining industry to produce gasoline, and small volumes of CO_2 are captured from power generation facilities to use in carbonated beverages and other products. These are but some examples of how CO_2 is captured and used in the U.S. today. U.S. industry also has expertise in transporting CO_2 with over 4,500 miles of CO_2 pipelines that move CO_2 around the nation today. Much of that CO_2 is used to enhance oil and gas recovery, and a significant amount of that CO_2 becomes trapped and securely stored in those oil and gas reservoirs. This has been done by the industry for nearly 50 years.

The U.S. has been a leader in the development of CCUS technology aided by the DOE's world class carbon capture and storage programs. Through the DOE carbon storage program, we have been storing large volumes of CO_2 in a variety of geologic reservoirs to prove out their ability to safely and effectively store CO_2. In addition, the DOE program is responsible for supporting the demonstration of carbon capture in a variety of industrial sectors. Through a federal grant, DOE supported the nation's first commercial-scale carbon capture demonstration project that is successfully operating on a coal-fired power plant in the U.S. – the Petra Nova project in Texas. This plant is integrating all of these processes into one project, and has captured over 2.5 million metric tons of CO_2, transporting it via an 82 mile pipeline to an oil field where the CO_2 is used to recover oil and securely stored in the oil reservoir.[17]

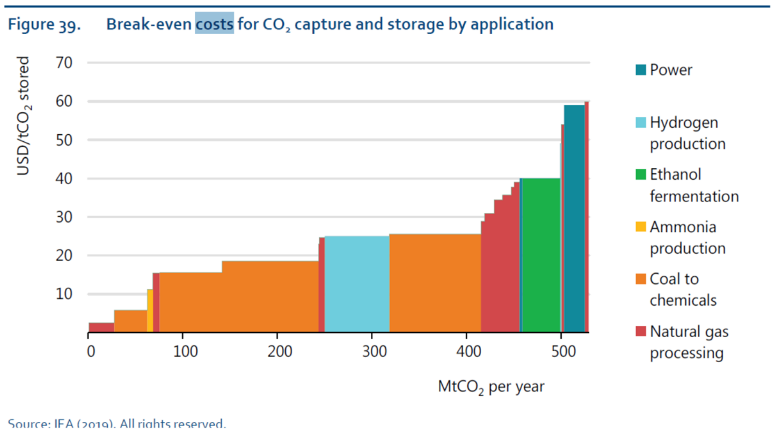
While the U.S. has an experienced industry and existing infrastructure to support the growth of a carbon capture industry, significantly larger volumes of CO_2 need to be captured, transported and stored at large-scale in order to achieve climate objectives.

(3) WHILE CARBON CAPTURE IS IN THE EARLY STAGES OF DEPLOYMENT TODAY, THE U.S. IS MAKING SIGNIFICANT STRIDES TO REDUCE COSTS AND CREATE A ROBUST CARBON CAPTURE INDUSTRY.

Recent analysis from the IEA indicates that while CCUS may be a competitive decarbonization solution for some industrial processes, such as gas processing, carbon capture projects remain expensive in some industries, including the power sector (see Figure 8). Thankfully, innovative research and development is underway to improve the cost and performance of new carbon capture technologies through DOE carbon capture and storage programs. The technologies in the DOE program portfolio have the promise of providing low- to zero-carbon, dispatchable power needed to support the growth of renewables and achieve the deep decarbonization goals for the U.S. power grid.

[17] https://www.nrg.com/case-studies/petra-nova.html and http://curc.net/webfiles/CCS%20101%20Briefing%20Series/Briefing%20%234/Update%20on%20DOE%20CCUS%20Program_6-25-2019.pdf

Figure 8 - Costs of CO2 Capture and Storage by Industry Application[18]



CURC members and the Electric Power Research Institute (EPRI) are constantly evaluating technology development needs that reflect the changing markets and policies that impact fossil fuel use. Every 2 to 3 years, those technology assessments are communicated through the publication of a "technology roadmap". Last summer, CURC and EPRI published the "2018 Advanced Fossil Energy Technology Roadmap" which identifies pathways to accelerate the development of fossil fuel generating options that include carbon capture, as the window for achieving transformational improvements in dispatchable generation is closing.[19] Over the next decade, a significant amount of coal and nuclear generation will be candidates for retirement. According to EIA data, the average age of coal and nuclear fleet will be, on average, 60 years of age in 2030. For power companies, the time between now and 2030 is a short time period for new generation planning, which typically spans a period of 10 to 15 years. That timeframe assumes existing units will not retire early due to economics or other market conditions that have led to recent premature retirements of coal and nuclear facilities. New, low- and zero-carbon emissions technologies that are cost competitive in the electricity market will be required to supply the dispatchable replacement capacity necessary to achieve deep de-carbonization of the electric grid.

The 2018 Roadmap reflects the technology development needs that can support an evolving U.S. power sector impacted by several emerging trends driving innovation and investment decisions for new generation. This includes a future generation fleet that will meet global decarbonization objectives. The Roadmap outlines several RD&D pathways for both new and existing coal and natural gas

[18] "Transforming Industry through CCUS", May 2019, International Energy Agency
[19] "CURC-EPRI Advanced Fossil Energy Technology Roadmap" July 2018, http://curc.net/curc-epri-advanced-technology-roadmap-1

technologies that can provide a suite of low- and zero-carbon, fossil fuel platforms capable of being cost competitive with other forms of electricity generation in future electricity markets.

Several technologies identified in the 2018 Roadmap will generate a new learning curve and result in new approaches for power generation and/or carbon capture to enable substantial breakthrough performance improvements and cost reductions (see Appendix). These encompass a broad range of technology improvements, including thermodynamic improvements in energy conversion and heat transfer, turbines and CO_2 capture systems that all drive cost reductions as well as reduce the consumption of energy needed to operate the CO_2 capture system. These technologies will result in a step change improvement in performance including low- or zero-carbon emissions, efficiency, flexibility, environmental performance and cost from the use of fossil fuels.

The novel power cycles identified in the 2018 Roadmap are designed to facilitate the capture of CO_2 at a lower energy penalty and cost than conventional methods. Example technologies in the Roadmap include pressurized oxy-combustion, chemical looping combustion, and supercritical carbon dioxide (sCO_2) cycles, which would replace steam with sCO_2 as the working fluid – including both the direct- and indirect-fired sCO_2 cycles. New turbines and other components to support the higher temperatures and pressures of these systems, particularly the sCO_2 cycles, are also considered. Each of these new technologies is projected to be extremely efficient, be more compact and lower cost, and are designed to yield lower costs and energy penalties associated with the capture of CO_2.

The Roadmap also considers carbon capture development paths for solvents, sorbents and membranes as well as hybrid approaches for post-combustion capture, and chemical and physical absorbents and membranes for pre-combustion capture systems, which are projected to have much lower energy penalties, yielding higher efficiencies and lower costs. Carbon capture technologies in the Roadmap address pathways for both coal-fired and natural gas combined cycle power plants. ***Importantly, our analysis determined that many technologies for carbon capture are applicable to both coal- and natural gas-fired power generation, through which public-private sector funding and support can be leveraged to develop technologies for applications using both resources, as well as for other industrial applications of the technology.***

The Roadmap also outlines a program for CO_2 utilization and storage, which is an important effort to evaluate geologic CO_2 storage reservoirs, necessary to ensure there will be readily accessible storage facilities for CO_2 produced from the advanced power systems under development. The 2018 Roadmap includes a program to advance technologies in this area. The Regional Carbon Sequestration Partnerships ("RCSPs") and the CarbonSAFE initiative are necessary for industry to advance technologies that will help grow our economy and increase our energy independence through the utilization of CO_2, and for which low-cost, industrial sources of CO_2 will be sought for enhanced oil and gas recovery. The Roadmap also identifies opportunities to convert CO_2 into other products, including chemicals, fuels and cement that should be pursued with federal RD&D support.

(4) INVESTMENTS IN CARBON CAPTURE WILL BENEFIT THE ENVIRONMENT, IMPROVE ENERGY SECURITY, AND PROVIDE MACROECONOMIC BENEFITS TO THE U.S. ECONOMY.

MACROECONOMIC BENEFITS

From an economic standpoint, investment in technology innovation and projects through the use of policies like the 45Q tax credits will stimulate growth in the carbon capture industry, which will create jobs and result in macro-economic benefits. CURC and ClearPath Foundation published an analysis titled "Making Carbon a Commodity: The Potential of Carbon Capture RD&D" that projects the macroeconomic benefits to the U.S. of new, lower-cost fossil energy technologies with CCUS as projected by the 2018 Roadmap.[20] The study estimates that if an aggressive RD&D program is implemented that achieves the projected Roadmap cost targets, market-driven deployment of 62 to 87 GW of power-sector projects with installed carbon capture technologies for enhanced oil recovery can be enabled by 2040.

Under an aggressive RD&D scenario that achieves the CURC-EPRI cost targets, the macroeconomic impacts of CO_2 captured from the power sector for use in enhanced oil recovery (EOR) can:

- Contribute up to 925 million barrels of annual domestic oil production
- Increase coal production for power by as much as 40% between 2020 and 2040
- Add 270,000 to 780,000 new jobs relating to increased oil production
- Result in a $70 to $190 billion increase in annual GDP by 2040.

The Making Carbon a Commodity study also estimates that lower-cost electricity generated from low-cost carbon capture-enabled systems also yield significant macroeconomic benefits. Aggressive RD&D is estimated to reduce the retail COE up to 2.0% by 2040, which would increase annual GDP by $30 to $55 billion and create an additional 210,000 to 380,000 jobs.

In addition, the new 45Q tax credit market is incentivizing investment opportunities for financial institutions as well as other types of investors. Similar trends resulted from renewable energy tax credits where a new financial market emerged for financing renewable energy projects due to the federal program. The new 45Q tax credit is causing financial institutions to evaluate investment opportunities in carbon capture projects. In the same way this resulted from the renewable tax credit market, new tools are being created for financial investors, which will improve efficiencies for project investment, act to reduce investor uncertainty and minimize perceived risks from investing in carbon capture projects.

[20] Making Carbon a Commodity: The Potential of Carbon Capture RD&D, CURC and ClearPath Foundation, July 2018, http://curc.net/making-carbon-a-commodity-the-potential-of-carbon-capture-rdd

ENERGY SECURITY BENEFITS

Innovation and investments in carbon capture for fossil fuel power generation will result in significant energy security benefits. These include:

a. producing and preserving affordable electricity for electricity consumers including increased industrial and advanced manufacturing customers, which is essential for U.S. competitiveness through a diverse generation technology portfolio;
b. improving the operational flexibility of existing and future generating plants to ensure continued electricity grid reliability and stability;
c. using captured CO_2 as a commodity to recover crude oil, thereby increasing domestic oil production; and
d. enabling U.S. engineering and manufacturing expertise to grow, resulting in a robust U.S. supply chain and positioning the U.S. to be even more of a global leader in innovative fossil-fuel technologies.

ENVIRONMENTAL BENEFITS

Investments in carbon capture will also have significant environmental benefits, including further reduction of water use and air pollutants, including nitrogen oxides (NOx), sulfur dioxide (SO2), mercury (Hg) and particulate matter (PM) (see Figures 9 and 10 below); as well as significant reductions of CO_2 emissions. The CURC-ClearPath study estimates a gigaton scale carbon capture opportunity with the potential deployment of up to 87 GW of carbon capture in the power sector.

Figure 9 - Emissions Reductions from a new Coal Unit Projected in the CURC-EPRI Roadmap

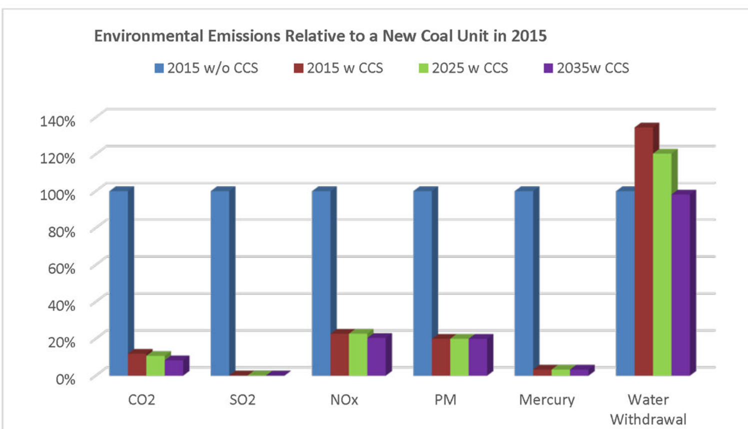
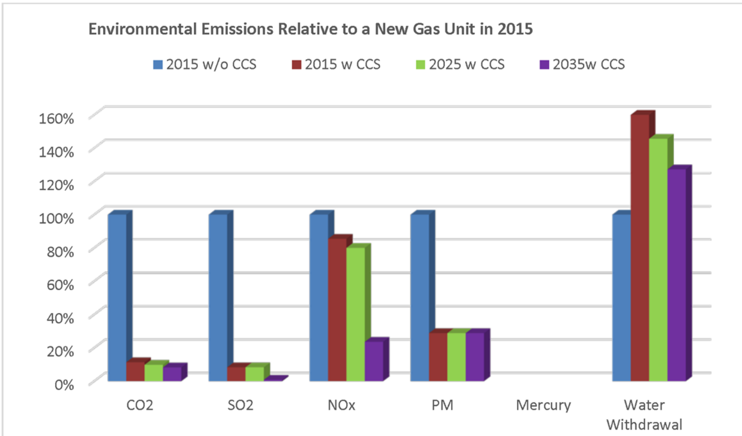


Figure 10 - Emissions Reductions from a new Gas Unit Projected in the CURC-EPRI Roadmap



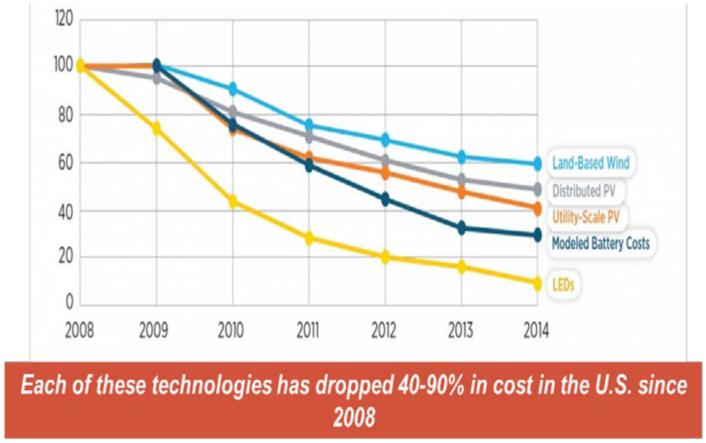
U.S. industry captures roughly 25 million metric tons of CO_2 annually using CCUS.[21] The 45Q tax credits have the potential to double or triple the amount of CO_2 captured and stored each year in the U.S. with the deployment of new carbon capture projects. The program is also incentivizing direct air capture projects which the UNIPCC has indicated will be necessary to achieve the below 2°C scenario, as well as projects that will convert CO_2 into other products and commodities, which will further reduce emissions.

(5) CARBON CAPTURE IS BIPARTISAN AND INDUSTRY AGNOSTIC. WITH ROBUST AND SUSTAINED POLICY SUPPORT, CARBON CAPTURE CAN CONTRIBUTE TO ANY DEEP DECARBONIZATION GOALS.

As carbon capture is still an emerging industry, economies of scale and best practices are not yet available that can result in efficiencies that will act to reduce the costs of implementation. If the technology innovation outlined in the 2018 Roadmap is coupled with robust and sustained deployment policies, the technology cost curve will come down and economies of scale will be achieved. In the same way the wind and solar industries were emerging as new technologies 15 years ago and not able to compete in electricity markets, fossil with CCS today cannot compete against other lower cost and subsidized forms of electricity.

[21] "Global Status of CCS", 2018, Global CCS Institute

Figure 11 - CCUS Costs Can Be Reduced with Robust and Sustained Policy Support[22]



To put this into perspective, Congress first authorized the wind production tax credits in 1992. It took 25 years of robust and sustained federal financial support for wind power to become cost competitive in electricity markets. Over the 25 year period, this amounts to roughly $23 billion in tax credits for electricity production from wind resources, not including the robust federal investments in research and development that were made or the state and regional policies that helped by requiring purchases of renewable power over that same period. While CCUS is further along in the cost and deployment curve than wind generation was even 15 years ago, it has not had the benefit of the same level or type of robust support until enactment of the 45Q tax credits in 2018.

Enactment of the 45Q carbon sequestration tax credits is one measure of the bipartisan support; a broad number of industries can implement carbon capture with the 45Q tax credits, which will be a key policy tool for catalyzing a carbon capture industry in this country. This policy will lower the cost of implementing carbon capture by providing a tax credit for every metric ton of CO_2 that is captured from industrial processes and stored in geologic reservoirs including oil reservoirs, or when the CO_2 is converted into other products like chemicals or used in cement production.

Project developers are eagerly awaiting issuance of Treasury guidance to understand how to be eligible for the tax credits in order for investments to flow into projects and meet the commence construction deadline to claim the 45Q tax credits. For the record, there are concerns that project developers are already up against the commence construction deadline, and to ensure this tax credit can be used in the way it was intended by Congress, it will be necessary to extend the deadline.

[22] U.S. Department of Energy, Office of Fossil Energy

Even as the U.S. continues to invest in the public-private partnership for research, development and demonstration of carbon capture, and in projects that will be incentivized from the 45Q tax credits, it is important to recognize that additional policy tools will help accelerate and attract investment in carbon capture projects in the same way Congress enacted several policy tools that resulted in the commercialization of other nascent energy technologies.

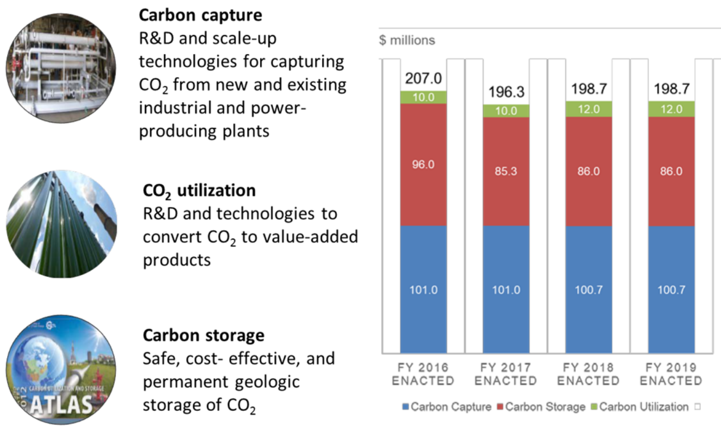
Several bills have been introduced that would put in place these policies and help to reduce the costs of implementing carbon capture in some industries. Some of those include:

- the "Utilizing Significant Emissions with Innovative Technologies" or "USE IT" Act (S. 383 / H.R. 1166), which would invest in carbon utilization and direct air capture research as well as streamline carbon capture and CO_2 pipeline infrastructure to help catalyze a CCUS industry;
- the "Carbon Capture Modernization Act" (S. 407 and H.R. 1796) which would modify the tax credit requirements to unlock nearly $2 billion in existing investment tax credits for carbon capture retrofits in the power sector;
- new authorizations to update the federal RD&D funding programs for carbon capture for fossil fuel power generation and for industrial capture through the "Fossil Energy Research and Development Act" (H.R. 3607) and the "Enhancing Fossil Fuel Energy Carbon Technology" or "EFFECT" Act (S. 1201); and
- two bills that would make carbon capture projects eligible for master limited partnerships (the "Financing Our Future Energy Act", (S. 1841 / H.R. 3249)), and private activity bonds (the "Carbon Capture Improvement Act", (S. 1763)) which are designed to help lower the cost of financing of carbon capture projects.

These are just some examples of the bills before Congress that have bipartisan support and that would complement the existing 45Q tax credit program. CURC welcomes the opportunity to work with this Committee in the evaluation of these policies and in the design of other policies that may be within the jurisdiction of this Committee to incentivize the development and deployment of carbon capture technology.

Other important policy tools for innovative research and development include federal funding for the DOE's carbon capture programs. Annually, Congress is funding the DOE carbon capture program at approximately $200 million per year (see Figure 12). The Roadmap recommends approximately double that for research, development, and testing of large scale pilot projects, with an additional $300/year over 10 years in funding for commercial demonstration projects.

Figure 12 - Department of Energy Funding for Carbon Capture and Storage Programs[23]



In addition to these DOE programs, in FY 2017, Congress appropriated $50 million DOE to undertake a new, transformational carbon capture pilot program, and has since appropriated an additional $60 million for the program (for a total of $110 million). In FY 2019, Congress appropriated an additional $30 million to undertake Front End Engineering and Design studies, which may prove to be a more cost-effective way for DOE to advance technologies within the R&D pipeline. Congress has also continued to fund the National Carbon Capture Center in Alabama, where critical testing on both coal- and natural gas-based carbon capture systems occurs.

CONCLUSION

U.S. investment in clean energy technologies, including those for coal, has resulted in the development and deployment of technologies that are in use all over the world today. Federal investments in all forms of clean energy have been a major return on the investment for both the U.S. economy and the global environment. As the U.S. continues to invest in carbon capture, we will benefit not only from cleaner power that is necessary to meet any deep decarbonization objectives, but also from new markets for U.S. technologies both domestically and abroad. Investment in CCUS technology will transform carbon dioxide into an economic resource, lower the cost of reducing emissions, create jobs, save consumers money, and safeguard our environment and demonstrate that the technology can be used here as well as around the world – paying dividends for generations.

[23] U.S. Department of Energy, Office of Fossil Energy

THANK YOU FOR THE OPPORTUNITY TO PROVIDE THIS TESTIMONY. APPENDIX - TECHNOLOGY PROGRAMS SUPPORTED IN THE 2018 CURC-EPRI ROADMAP

Transformational Advanced Energy Systems		
Pressurized Oxy-Combustion (P-Oxy)	Coal and Natural Gas	Oxy-combustion power plants remove nitrogen from air cryogenically and perform the combustion of fossil fuels with oxygen and recycled flue gas to produce a stream largely comprised of CO_2 and water, greatly simplifying carbon capture. P-Oxy operates at elevated pressure, improving efficiency and allowing smaller components that combine to potentially reduce costs.
Chemical Looping Combustion (CLC)	Coal and Natural Gas	CLC is a form of oxy-combustion in which oxygen from air is separated using a metal oxide or limestone oxygen carrier, eliminating the need for cryogenic air separation and its significant energy penalty, while maintaining the relatively easy carbon capture provided by oxy-combustion.
Direct-Fired Supercritical CO_2 (sCO_2) Cycles	Coal and Natural Gas	A form of oxy-combustion, direct-fired sCO_2 cycles burn natural gas or syngas (provided by coal gasification) in a high-pressure oxy-combustor, producing very high-temperature CO_2 and water that drive a sCO_2 turbine to make power. Water and CO_2 (at pipeline pressure) are then removed downstream to conserve mass, producing a very-high-efficiency, potentially low-cost carbon capture system.
Indirect-Fired sCO_2 Cycles	Coal and Natural Gas	Replace steam-Rankine cycles with sCO_2 cycles which, due to the superior thermodynamic qualities of CO_2, have higher efficiency and utilize more compact turbomachinery. Can be used on any cycle that currently uses a steam-Rankine cycle, including solar thermal, geothermal, nuclear, biomass and any type of fossil fuel. The process results in higher efficiency and can be coupled with a low-cost carbon capture system.
Gasification	Coal	Coal can be gasified in either an air- or oxygen-blown gasifier to produce synthetic gas (syngas) that can be used in an efficient integrated gasification combined cycle system. Pre-combustion carbon capture can be added. New, highly efficient, compact gasifiers can be used in poly-generation plants that combine electricity generation with co-production of transportation fuels, fertilizer and/or other chemicals to improve the overall economics.
Compact Hydrogen Generator	Natural Gas	New, highly efficient method for producing hydrogen (alternative to steam-methane reforming).

Cross-Cutting Technologies		
A-USC Materials	Coal and Natural Gas	A-USC materials are needed to allow working fluid temperatures up to 760°C to support highly efficient combustion and heat exchange systems for both steam-Rankine and sCO_2 power systems and other high-temperature technologies. Can be applicable to both new and existing plants.
Turbines	Coal and Natural Gas	RD&D and testing of steam turbines, combustion turbines, and sCO_2 turbines and pressure-gain combustion, all in an effort to improve efficiency, reliability and flexibility and support power systems evaluated in the Roadmap.

Transformational Advanced Energy Systems		
CO_2 Capture	Coal and Natural Gas	Advances in solvents, sorbents and membranes for both pre- and post-combustion carbon capture focused on lowering energy requirements and overall cost of capture. Technologies will need to be adjusted to handle the differences between coal and natural gas flue gas, which include different CO_2 concentrations and trace species.
CO_2 Storage	Coal and Natural gas	Saline reservoirs, enhanced oil and gas recovery, and other geologies are being explored for storing CO_2 both onshore and offshore. RD&D as well as large-scale CO_2 storage and regional infrastructure strategies related both to storage and transportation in the U.S. are needed
Existing Plants	Coal and Natural Gas	RD&D to support flexibility and reliability of operations of existing plants
Cross-Cutting	Coal and Natural Gas	RD&D on technologies that support all Roadmap areas, including: • Advanced manufacturing • Breakthrough technologies • Sensors and controls • Water management

BIOGRAPHY

Shannon Angielski

Principal, Governmental Affairs, Van Ness Feldman

Executive Director, Carbon Utilization Research Council

Shannon Angielski is a principal at Van Ness Feldman LLP, a Washington D.C. based law firm that specializes in energy, environment and natural resource policy and law, and serves as the Executive Director of the Carbon Utilization Research Council (CURC). CURC is a coalition of producers, electric utilities that rely upon coal and natural gas for electricity production, gas distributors, equipment manufacturers and technology innovators, national associations, and state, university and technology research organizations (see www.curc.net). Members of CURC coalesce around the need for technology solutions to ensure the responsible use of our fossil energy resources in a balanced, low carbon generation portfolio. They serve this mission by evaluating technology development needs, developing policies and public-private programs to advance technology solutions, and by advocating for the advancement of those policies with policymakers, NGOs and other stakeholders. Advancing carbon capture, utilization and storage is a key component of the policy portfolio that CURC serves.

Shannon earned her M.S. in Environmental Science and Public Policy from Johns Hopkins University in 2000 and her B.A. in Political Science and International Affairs from the University of New Hampshire in 1994. She is a member of the National Coal Council, and serves on the board of the Washington Coal Club.

CURC MEMBERSHIP

Power Producers
Basin Electric Power Cooperative
Duke Energy Services
LG & E and KU Services Company
Southern Company
Tri-State Generation & Transmission Association

Equipment Suppliers
General Electric
Mitsubishi Heavy Industries America, Inc. (MHIA)

Labor Unions
International Brotherhood of Boilermakers
International Brotherhood of Electrical Workers

NGOs
ClearPath Action
EnergyBlue Project

State Organizations
Southern States Energy Board
Wyoming Infrastructure Authority

Coal Producers
Arch Coal, Inc.
Cloud Peak Energy Resources LLC
Lignite Energy Council
Peabody Energy

Research Organizations
Battelle
Electric Power Research Institute (EPRI)
Gas Technology Institute
University of North Dakota Energy & Environmental Research

Technology Developers
ION Engineering
Jupiter Oxygen Corporation
NET Power

Trade Associations
American Coal Council
American Coalition for Clean Coal Electricity (ACCCE)
Edison Electric Institute (EEI)
Energy Policy Network
National Rural Electric Cooperative Association (NRECA)

Universities
Lehigh University
Ohio State University
Pennsylvania State University
Southern Illinois University
University of Illinois/PRI
University of Kentucky/CAER
University of Wyoming
West Virginia University

Mr. TONKO. Thank you, Ms. Angielski.

And Mr. Cohen, you are recognized for five minutes, please.

STATEMENT OF MR. COHEN

Mr. COHEN. Chairman Tonko, Ranking Member Shimkus, and distinguished members of the committee, I appreciate the opportunity to testify this morning.

Rather than read a written statement, I presented or prepared several slides and visuals that I think I want to just walk you through to kind of connect some of the threads you have already heard. It is labelled supporting slides.

So if you turn with me to the first page, there's a pie chart and it is U.S. energy CO2 emissions by sector. And so we talk a lot about electricity but as some of the previous speakers have mentioned, it is not just about electricity. Actually, electricity is 40 percent of the CO2 energy problem in the United States. Agriculture is—you know, I will put it in a separate category.

The point is there are many sectors to address here. We have got a $2 trillion a year energy economy that we have to decarbonize over a period of decades.

My bottom line is that it is tough but feasible if we retain options to go down multiple pathways at once and those pathways are represented in the next slide, which is called puzzle pieces for a 100 percent carbon-free energy economy, and there you can see that we have to do a number of things simultaneously, some of which have been mentioned.

We need—we can utilize variable zero-carbon electricity that we have today at low cost like wind and solar and with storage.

We will need firm always available zero-carbon electricity to balance the grid. I will get to that in a minute. We will need carbon capture and storage. We will need electrification.

We will need low-carbon industrial processes, and at the center of this puzzle diagram you will see something called zero-carbon fuels, which are essential to making all of this work. If we have a zero-carbon drop-in liquid or gaseous fuel to substitute for current gas and oil, we have really a winning combination.

Finally, there is something in this—there is a puzzle piece called super pollutants, which is really dealing with methane leakage from the fossil fuel system, which we will have to do with fossil energy as to be part of this decarbonized future.

The next slide is a somewhat complicated diagram but I won't walk through in detail. But it is called a zero-carbon energy system. The point that is made here is that we need to succeed. We are going to need a complementary set of technologies.

You will see that zero-carbon electricity is kind of at the core because you can do a lot, as Dr. Hausker has recommended, in terms of building decarbonization industry and transport. But we are going to need some other things, and to the left of the zero-carbon electricity diagram you will see hydrogen, and we would add to that hydrogen-derived fuels like ammonia, which can be used as substitutes for gas and oil.

The way that we create zero-carbon electricity through renewables, through nuclear energy, and through fossil energy with carbon capture, interestingly, there are a lot of crossovers in here and complementarities among these technologies.

So, for example, you will see towards the bottom of the page that kind of all roads lead to carbon capture, as has been mentioned. Carbon capture really does triple duty.

It can decarbonize electricity. It can help create zero-carbon fuels for transport, and it can help create zero-carbon fuels for industrial heat and process.

So very, very critical lynchpin technology, electrolysis and hydrogen transformation as well, and you will see that nuclear also plays a role in this picture along with renewable.

So an overarching point is there has been a lot of talk about Apollo 11 in the last week, rightly so. But my view is this is not about moon shots. This is about test flights and it is about some smart earthbound engineering.

Most of what is in these diagrams has already been demonstrated. Not all of it has been demonstrated or built multiple series at commercial scale but it has all fundamentally been demonstrated.

Whether it is nuclear or carbon capture, it is about smart engineering, it is about getting into mass production, and bringing costs down.

Let me close by addressing the electric part of this equation, which, as we have mentioned, is absolutely critical. We have a great head start on electricity. A third of the United States power grid is already decarbonized.

Between hydroelectric, wind and solar, and nuclear, we are now a third of the way there. So we need to get the other two-thirds of the way there. So how do we do that?

As was mentioned, we have an enormous accomplishment to be proud of, which is the degree to which wind and solar costs have come down.

I have no doubt that they will be the backbone of a future decarbonized electric grid. But that may not be the whole solution.

They might be, but I believe that there is reason from the modelling and the analysis that has been done, which I am going to walk you through in the next minute. We can talk about that at greater length in the Q&A.

To demonstrate why we need things in addition to variable weather dependent electricity, if you turn to slide four you will see—I took the example of California because it is a state that is blessed with renewable resources and also a state that is very dedicated to decarbonizing its grid and has actually put that into law.

You can see that wind and sun vary by season. If it were just a question of daily wind and sun variability, we could do that with battery storage pretty cheaply.

But the fact is we have seasonal variations and you can see a factor of 400 or 500 percent variation for months over the year. If you—at the bottom of slide four you will see the demand in California, which is pretty constant throughout the year.

But you will see that the available resource—wind and solar resource combined—fluctuates quite a bit over the year over seasonal patterns. And if you flip the page to slide five, you will see that the result is that we have what essentially is a seasonal surplus and a seasonal deficit.

That is very expensive to deal with with battery storage, even if we dropped the price of batteries by, say, 80 percent.

My final slide just shows that if we go to a system that is, let us say, half renewables, we probably have modest costs right now and we can manage that with storage.

If we push a lot farther than that right now without firm energy in the system, which would be the light blue bars, we are looking at a very steep incline.

So bottom line is firm energy, zero-carbon energy very important and we can address that in the Q&A.

Thank you.

[The prepared statement of Mr. Cohen follows:]

Before the United States House of Representatives
Committee on Energy and Commerce
Subcommittee on Environment and Climate Change

"Building America's Clean Future: Pathways to Decarbonize the Economy"

Testimony of Armond Cohen, Executive Director, Clean Air Task Force

July 24, 2019

SUMMARY OF TESTIMONY

Earth's atmosphere has more carbon dioxide than at any time in human experience, most of it added in the last half century. To preserve a natural world anything like we have known, we need to build a 100% carbon-free energy economy by 2050, and then progressively withdraw some of the carbon we have put into the skies already.

Building a 100% carbon-free energy economy by 2050 is tough but achievable. It will require assembling a complete set of solutions across all sectors, including clean, carbon-free electricity, zero-carbon fuels, and decarbonized industrial processes. States like New York, California, Colorado and New Jersey have taken legislative or planning actions toward a completely carbon-free economy and more are considering it. Eight states have firmly committed to carbon free electricity by mid-century, as have many major utilities such as Xcel Energy, MidAmerican, and Idaho Power.

Zero-carbon electricity is critical, and its importance will grow as electricity use expands in transportation, heating, and industry. But it is insufficient. Some emissions sources, including high-temperature industrial process heat and long-distance transportation, will be very difficult if not impossible to electrify. Zero-carbon fuels (such as ammonia, hydrogen and synthetic hydrocarbons) are needed to decarbonize these activities. Emissions from direct industrial processes such as steel and cement are big too; to address them, we will need carbon capture and sequestration or new inherently carbon-free processes. It is best to think of a zero-carbon energy economy as a system with interlocking and mutually supporting options. Federal and state government policy can help accelerate innovation to create that system.

We have a good head start on electricity: the U.S. grid is already a third carbon-free with wind, solar, hydroelectric and nuclear power. Wind and solar have dropped in price and grown to 8% of our total supply electricity, and battery storage is getting cheaper too. That is great news and these sources have a long way to grow – to many times their current level. But the best way to build a 100% clean, carbon-free electricity system is to harness a complete portfolio of resources, including wind, solar, storage, and firm low-carbon resources. Having multiple firm resources to complement power from the wind and sun is not only the most affordable but also the lowest-risk way to achieve our goal. Such a system will also help us decarbonize transportation and industry through electrification. Congress should build on momentum from the states and enact policies to transition to 100% carbon-free electricity nationwide harnessing all available carbon-free sources, and enact innovation policies and incentives to support the full suite of carbon-free options.

Natural gas with carbon capture is one option for a zero carbon grid. Hydrogen could also be an important way to decarbonize electricity and fuels for industry and transportation; it can be made by renewable and nuclear energy but, at present, by far the cheapest route to hydrogen is from natural gas with carbon capture and storage. However, to play a major role in climate mitigation via either power or fuels, natural gas will need to virtually eliminate its collateral emissions of the super pollutant methane, which packs more warming punch than carbon.

In short, we have many of the tools in view for a carbon free-energy economy by mid-century, and good momentum to build on. We need to commit to binding emissions targets or other economy-wide carbon pricing policies calibrated to reach zero emissions by mid-century, while expanding the technology toolkit by supporting technology incentive policies that will deliver additional affordable zero-carbon energy options in time. Clean Air Task Force commends the leadership of this committee for taking the first step in its announcement that it will produce by the end of 2019 comprehensive climate legislation to create a zero-carbon economy by midcentury.

Chairman Tonko, Ranking member Shimkus, and distinguished members of the Subcommittee:

My name is Armond Cohen and I am Executive Director of Clean Air Task Force, an environmental organization dedicated to the protection of Earth's atmosphere, focusing especially on strategies to commercialize carbon-free energy. I appreciate the opportunity to testify today.

1. *We need a carbon-free energy system by mid-century, not just carbon free electricity*

Earth's atmosphere has more carbon dioxide than at any time in human experience, most of it added in the last half century. To preserve a natural world anything like we have known, need to build a 100% carbon-free energy economy by 2050, and then progressively withdraw some of the carbon we have put into the skies already. And, achieving climate stabilization targets, as Figure 1 below shows, will require essentially zeroing out energy-related greenhouse emissions from all sectors of the economy around 2050. That means not just the electric sector, but also transportation, industry, buildings and agriculture. And we must accomplish this as global demand for energy could as much as double in the coming decades, as developing economies get richer. (See Figure 2 below). So, U.S. comprehensive climate legislation with the goal of zero-carbon emissions by midcentury must cover all of these sectors.

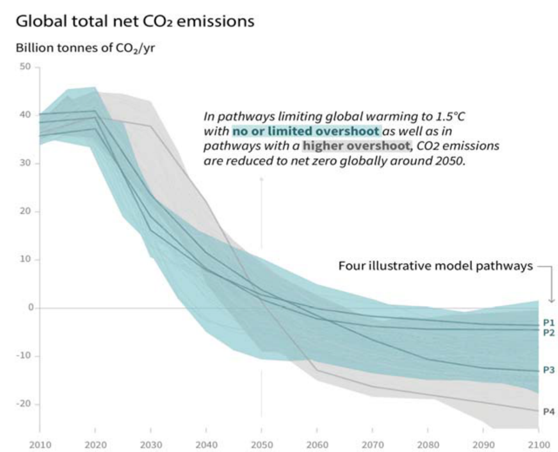


Figure 1: Pathways to limit global temperature to the Paris Agreement target of no more than 1.5 degree warming (Source: IPCC, Special Report: Global warming of 1.5^0 C, 2018)

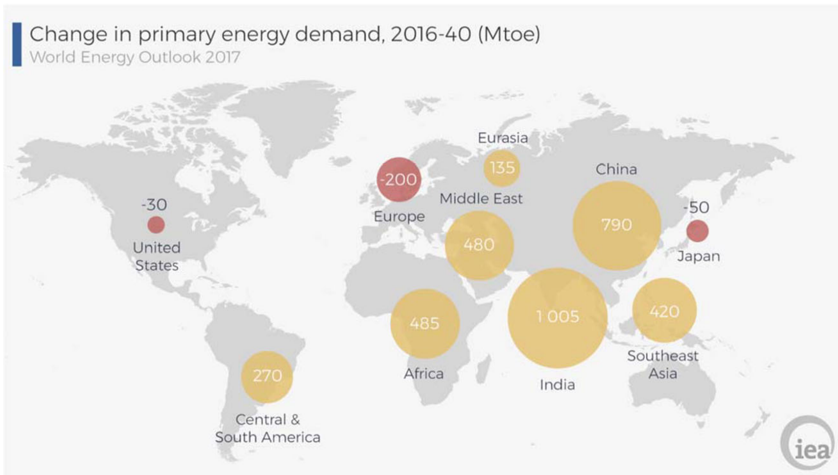


Figure 2: Projected energy demand increases in the coming decades. Source: International Energy Agency, World Energy Outlook 2017.

Although there are significant challenges, the pathway to a carbon-free economy is in concept straightforward: replacing existing greenhouse gas-emitting energy sources with zero-emitting resources and building additional zero-emitting resources to meet future growth. Eventually, we will also likely need to progressively withdraw some of the carbon we have put into the skies already. [1]

The conclusion: Building a 100% carbon-free energy economy requires assembling a complete set of solutions across all sectors, including clean, carbon-free electricity, zero-carbon fuels, and carbon-free industrial processes.

We have a good head start on electricity: the U.S. grid is already a third carbon-free with wind, solar, hydroelectric and nuclear power. Wind and solar have dropped in price and grown to 8% of our total supply electricity, and battery storage is getting cheaper too. Carbon-free electricity is critical, and its importance will grow as electricity use expands in transportation, heating, and industry. But it is insufficient.

Today electricity and associated by-product heating are responsible for less than half of all energy-related carbon emissions; transport, building, industry and other sources represent the dominant share. (See Figure 3 below).

[1] This testimony addresses creating a carbon-free energy supply. It does not address energy efficiency improvements, carbon in agriculture, which represents roughly 25% of the greenhouse gas emissions problem, or carbon dioxide removal. We assume those topics will be covered in future hearings of the subcommittee.

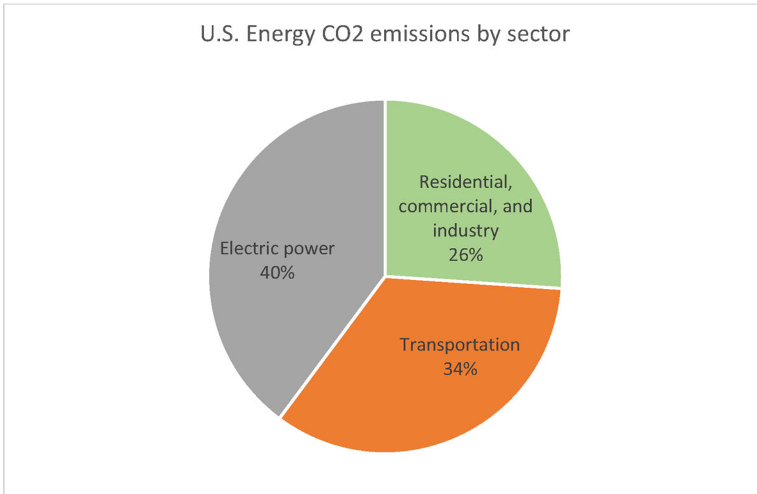


Figure 3: US CO2 emissions by sector. Source: US Energy Information Administration (2011).

While it is important to decarbonize our power grids, and electrify as much as we can of industry, transport and building heat, there are steep challenges to electrification that are likely to leave a large residual emissions footprint.

For starters, as Figure 4 illustrates, about half of CO_2 emissions from three large emitting industries come from chemical processes (e.g. iron reduction, chemical reactions in cement), not from energy use:

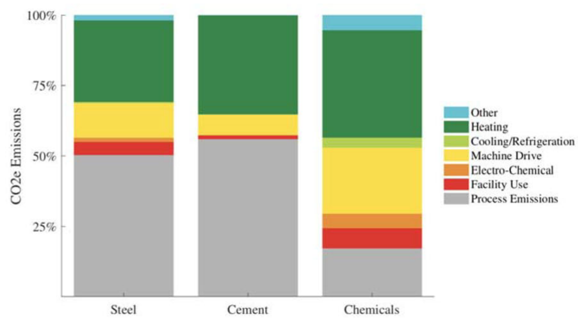


Figure 4: Carbon emissions from US heavy industries, by source. Source: US EPA (2018)

Additionally, a substantial portion of the heat-related portion of heavy industry emissions comes from ***high temperature heat***, typically greater than 400 degrees C, which is not readily economically supplied by electricity. (See Figure 5 below).

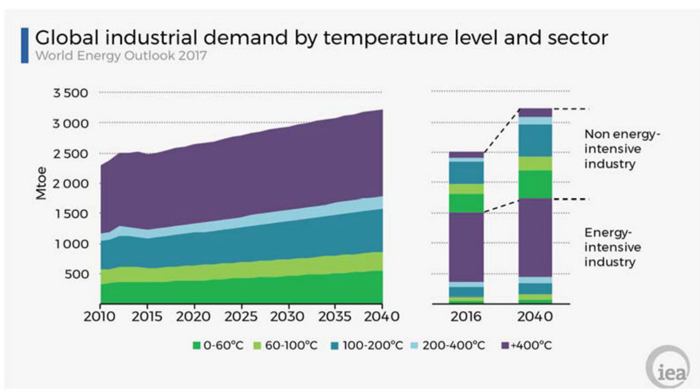


Figure 5: Heavy industry heat requirements. Source: International Energy Agency, World Energy Outlook (2017)

Electrification is an important option for transportation but there are several challenges here as well. The most obvious place to start is light duty cars and trucks, and some nations and states have shown increasing penetration of electric vehicles in new car sales. But all-electric vehicles in 2018 represented just over 2% of new US car sales; concerns over range and charging times persist. And even assuming all light duty vehicles were electrified, 40% of transport fuel use and

GHG emissions come from sources other than light duty vehicles, such as heavy freight, aviation, and shipping. (See Figure 6 below).

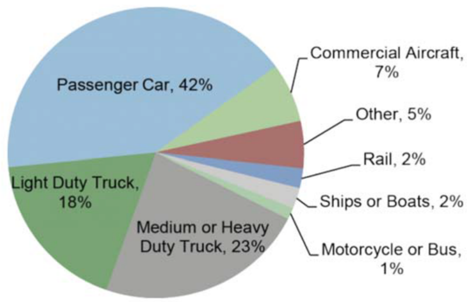


Figure 6: Greenhouse gas emissions by transportation sub-sector. Source: University of Michigan (2018)

Although prototypes of fully electrified medium and heavy-duty trucks have emerged, battery size and weight remain a substantial challenge.

Where we cannot replace emitting energy sources with carbon-free electricity, four additional and overlapping energy pathways could be critical and should be addressed in comprehensive climate legislation or enacted as complementary policies:

- Zero-carbon liquid or gaseous fuels that can be used for transport, high temperature industrial heat, and building heat (and to create firm, non-weather-dependent electricity)
- Direct sources of zero-carbon high temperature heat such as supercritical geothermal energy and high temperature nuclear energy
- Industrial processes that do not inherently produce carbon emissions
- Direct carbon capture for otherwise unavoidable industrial carbon emissions

Note that there are a variety of interconnections and complementarities between these pathways and pathways for carbon-free power sector. For example, zero-carbon liquid or gaseous fuels can be made (a) via electrolysis of water which requires zero-carbon electricity, but also by (b) stripping carbon from responsibly-sourced natural gas through steam reforming and carbon capture and (c) direct chemical conversions using nuclear energy.[2] Likewise, carbon capture is not only useful for directly capturing power and industrial emissions, but also for decarbonizing industrial heat or producing carbon-free hydrogen from natural gas. And zero-carbon fuels, as well as nuclear and carbon capture, as discussed below, can be important enablers of a zero-carbon electric grid in complement to wind, solar and energy storage.

[2] See Clean Air Task Force, "Fuel Without Carbon" (2018), https://www.catf.us/wp-content/uploads/2018/12/Fuels_Without_Carbon.pdf

I was honored last year to be part of a group of authors who published an article in *Science* entitled "Net-zero emissions energy systems." [3] The key insight of that article is that it is best to think of a net-zero greenhouse gas emissions energy economy as a ***system*** of complementary and overlapping parts. These parts include zero-carbon electricity, fuels, storage, low-carbon industrial processes, and carbon capture and sequestration from fossil fuel use. A greatly simplified schematic picture of such a system can be seen in Figure 7 below.

[3] Davis, Steven J., et al. "Net-zero emissions energy systems." *Science* 360.6396 (2018): eaas9793.

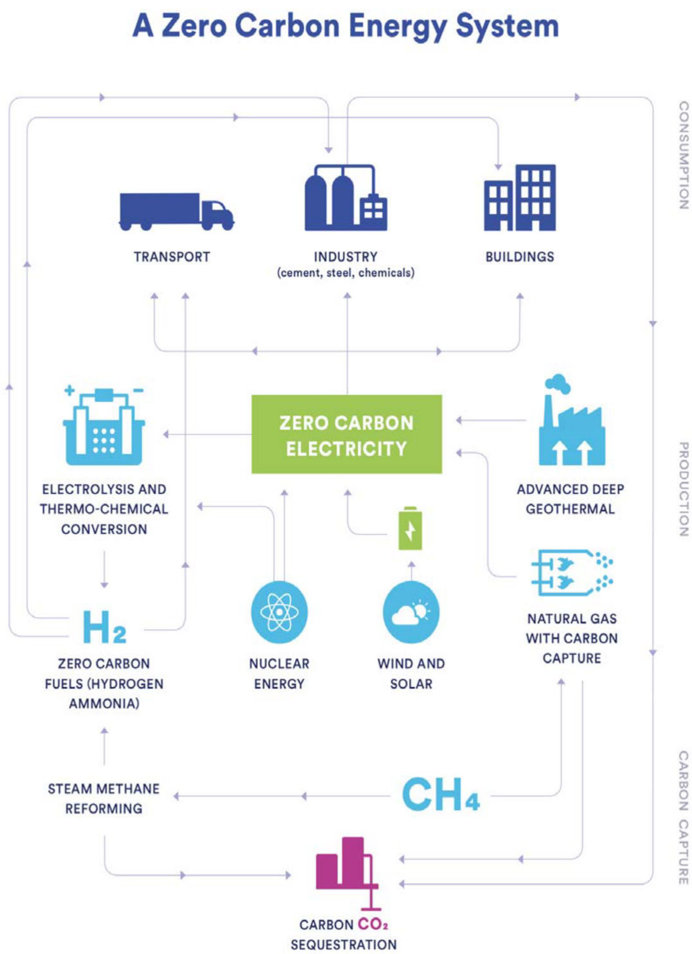


Figure 7: Schematic of a zero-carbon energy system (Source: Clean Air Task Force, 2019)

It is just such a system that we must assemble globally in the next several decades. This will require innovation across a broad range of technologies, and innovation policies to drive that innovation, which I am sure will be the subject of future hearings held by this subcommittee.

2. ***The best way to build a 100% clean, carbon-free electricity system is to harness a complete portfolio of resources, including wind, solar, storage, and firm low-carbon resources. Congress should particularly emphasize innovation and policy support for firm resources to complete the clean electricity portfolio.***

We have an abundance of potential technology options available now and likely to be available in the future to meet the goal of zero-carbon emissions on the US power grid. As noted, solar and wind energy costs have come down substantially in recent years, and supply a little over 8% of today's electricity; there is plenty of headroom to grow them. Energy storage which can balance variability of solar and wind has also dropped in price. Parts of the US are also blessed with hydroelectric resources within the state (and from our neighbor Canada), providing 7% of our electricity. Nuclear energy provides another 19%. As a result, the U.S. grid is already a third decarbonized.

Moreover, emerging technologies are in place today, and more are coming forward, which can make use of responsibly-sourced natural gas for power generation with minimal carbon dioxide emissions to the atmosphere, utilizing carbon capture and sequestration.[4] In addition, multiple companies are working to bring to market new nuclear plants that may be less expensive and even safer than today's technology.[5] There may be the opportunity for advanced geothermal power using injection of water into deep hot rock formations, which could provide on-demand steam to generate electricity.[6] And there will be some role for climate-beneficial bioenergy as well.[7]

If we keep all of our options and enact supporting policies to make them even more viable, we stand a good chance of meeting a mid-century target of 100% carbon-free electricity. Nations and regions such as Sweden, France, Ontario, and Brazil have already achieved extremely low electricity carbon emission rates through use of some of these technologies, chiefly hydroelectric, wind and nuclear energy.

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[4] See R. Service, "Goodbye smokestacks: startup invents zero emissions fossil power," *Science,* May 24, 2017, https://www.sciencemag.org/news/2017/05/goodbye-smokestacks-startup-invents-zero-emission-fossil-fuel-power

[5] See Clean Air Task Force, "Advanced Nuclear Energy: Need, Characteristics, Projected Costs, and Opportunities" (April 2018), https://www.catf.us/resource/ane-need-characteristics-project-costs/

[6] See presentation from a recent Clean Air Task Force-sponsored symposium, https://www.catf.us/resource/catf-eon-geothermal-workshop/

[7].See Appendix 1 for a discussion of opportunities and limits to bioenergy as part of deep decarbonization.

Policy is moving in this technology-inclusive direction. States like New York, California, Colorado and New Jersey have taken legislative or planning actions toward a completely carbon-free economy and more are considering it. Six states in the last year – California, New Mexico, Nevada, Colorado, Washington State, and New York – enacted so-called "Clean Energy Standard" legislation to require their grids, or portions thereof, to be supplied ***zero-carbon*** emitting generation, not entirely by renewable generation – representing 15% of US power sales.[8] Similar technology-inclusive targets are being debated in Illinois and Wisconsin. (See Figure 8 below). In addition, electric utilities such as Xcel Energy, MidAmerican, and Idaho Power have also committed to technology-inclusive, 100% carbon-free power supply by midcentury.

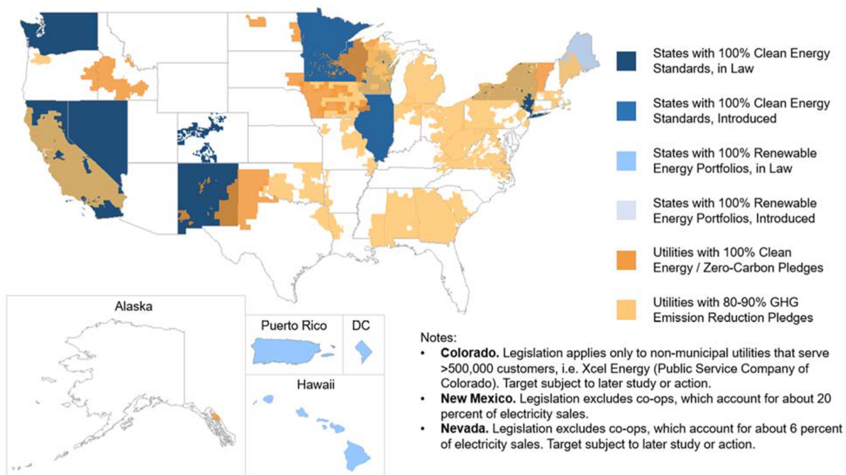

Figure 8: Map of State laws enacted and proposed, and power company carbon pledges (compiled by Clean Air Task Force, June 2019, https://www.catf.us/resource/state-utility-climate-change-targets/)

Moreover, in addition to supporting renewable energy and storage, Congress has in the past year demonstrated bipartisan support for firm, zero-carbon power in enacting policies to help bring advanced nuclear, carbon capture and storage, and other advanced energy technologies to market including the 45Q tax credit for carbon storage[9], the Nuclear Energy Innovation and Modernization Act (NEIMA)[10], and the Nuclear Energy Innovation Capabilities Act (NEICA)[11] in

[8] Hawaii Maine, Washington DC, Puerto Rico have opted for 100% renewable electricity targets.
[9] 26 U.S.C §45Q.
[10] Public Law No. 115-439
[11] Public Law No: 115-248.

the 115th Congress and the current Congress appears poised to move other important clean energy legislation this year.[12]

Here I want to focus specifically on the importance of policies such as Clean Electricity Standards that keep the door open for "firm" zero-carbon energy sources in a 100% zero-carbon grid. Firm sources are those that are available on demand, any time of year, for as long as needed. Firm sources are thus not dependent on weather and are a critical complement to wind and solar power. Firm low-carbon resources include, today, fossil fuels with carbon capture and storage, nuclear energy, and hydroelectric power and bio-energy.[13] In the future, as noted, they could include advanced geothermal and perhaps advanced cellulosic biofuels or combustion of zero-carbon fuels such as hydrogen or ammonia derived from electrolysis from zero-carbon energy, steam reforming of natural gas combined with carbon capture, or nuclear energy.[14]

a. *Technology diversity reduces the cost of a carbon-free electric system*

Why is firm zero carbon energy important? First is the issue of cost. A recent review of 40 studies concluded that the most affordable path to 100% clean, carbon-free electricity is to combine wind and sun with firm carbon-free electricity sources.[15] A typical recent detailed analysis of the role of firm energy in a Northeast and Southern electric system found a dramatic cost difference between 100% clean electric systems that harness wind, solar, and firm resources and those that rely solely on wind and sun.[16] (See Figure 9 below).

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[12] See e.g., Senate Energy and Natural Resources Committee https://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=1F661065-9C39-4A6B-B044-12FA17DD6FDD; House Energy and Commerce Committee https://energycommerce.house.gov/committee-activity/markups/markup-of-26-bills-full-committee-july-17-2019

[13] Hydroelectric power output can vary with climate conditions, and dispatch can be constrained in some cases by environmental considerations that affect reservoir management. It should be noted that there are unsettled issues around greenhouse gas emissions from large hydroelectric reservoirs, even in northern latitudes. See, e,g, Scherer, Laura, and Stephan Pfister. "Hydropower's biogenic carbon footprint." *PloS one* 11.9 (2016): e0161947. See Appendix 1 for a discussion of opportunities and limits to bioenergy as part of deep decarbonization

[14] See Clean Air Task Force, "Fuels Without Carbon: Prospects and the Pathway Forward for Zero-Carbon Hydrogen and Ammonia Fuels" (December 2018) https://www.catf.us/resource/fuels-without-carbon/

[15] Jenkins, Jesse D., Max Luke, and Samuel Thernstrom. "Getting to Zero-carbon Emissions in the Electric Power Sector." *Joule* 2.12 (2018): 2498-2510. (Link here)

[16] Sepulveda, Nestor A., et al. "The role of firm low-carbon electricity resources in deep decarbonization of power generation." *Joule* 2.11 (2018): 2403-2420. ("Across all cases, the least-cost strategy to decarbonize electricity includes one or more firm low-carbon resources. Without these resources, electricity costs rise rapidly as CO_2 limits approach zero. Batteries and demand flexibility do not substitute for firm resources. Improving the capabilities and spurring adoption of firm low-carbon technologies are key research and policy goals.") (Link here).

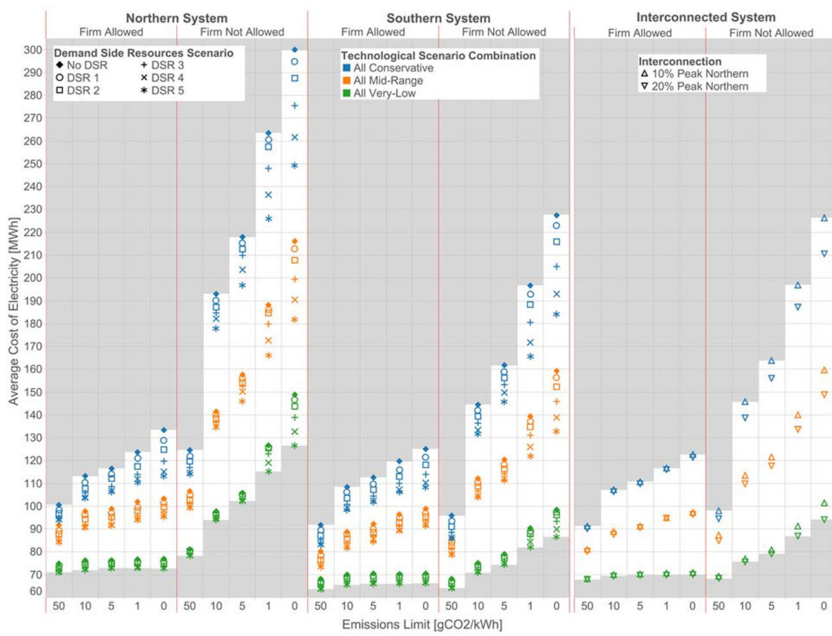

Figure 9: Costs of achieving zero-carbon grids are much higher where form resources are not allowed and only wind, solar and storage are permitted. Used by permission from Sepulveda, Nestor A., et al. "The role of firm low-carbon electricity resources in deep decarbonization of power generation." *Joule* 2.11 (2018): 2403-2420

To further illustrate the cost advantages of a full portfolio of wind, solar, and firm resources, I will consider data for California. I have chosen California because it is a state rich in wind and solar resources, a state committed to eliminating carbon emission from its power grid by 2045, but also a state that adopted technology-inclusive portfolio approach: its new law, SB 100,[17] requires 60% of the state's electricity to come from renewable sources but allows for other technology families to comprise the balance.

The fundamental dynamic driving the need for firm energy is ***seasonal variability***. It is commonplace to say that "the wind doesn't always blow and the sun doesn't always shine." But this statement does not capture the real challenge of a wind- and sun-dominated electric system. Wind and sun do not just vary on ***daily*** cycles; they vary substantially over ***weekly*** and ***monthly*** periods.

[17] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100

This seasonal effect can be seen in California for wind in Figures 10-11 below, illustrating smoothed, daily-average production[18] for onshore wind and solar photovoltaics:

Smoothed Daily Average Wind Production in CAISO, 2018 (MW)

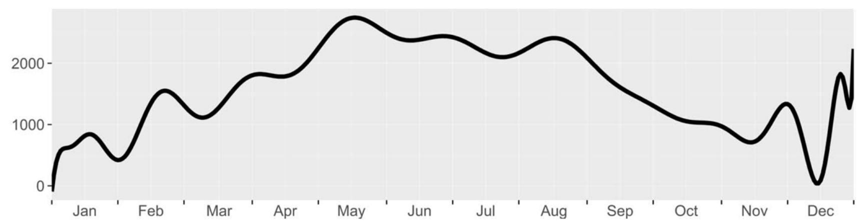

Figure 10

Smoothed Daily Average Solar Production in CAISO, 2018 (MW)

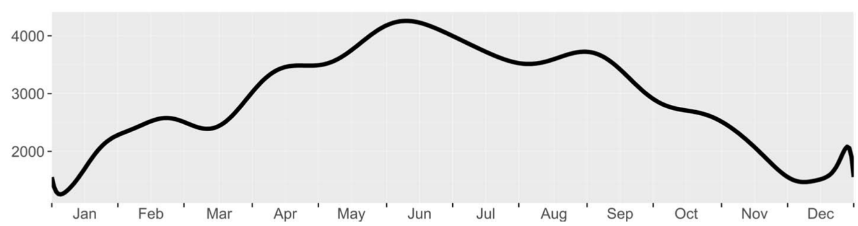

Figure 11

We see a variation in output plus of 300% or more between seasons.

What happens when we combine wind and solar output to equal 100% of California electric demand on an annual basis, and contrast it to actual demand in each day, week and month? Assuming that we have a 50% wind/50% sun system, we get a pattern like Figure 12 below:

[18] This daily average smoothing conceals more significant variability *within* the day.

Smoothed Daily Load & Renewable Energy Generation, Mixed Renewable Scenario (MW)

Scenario definition: 2018 wind and solar generation scale to each meet 50% of total 2018 CAISO load

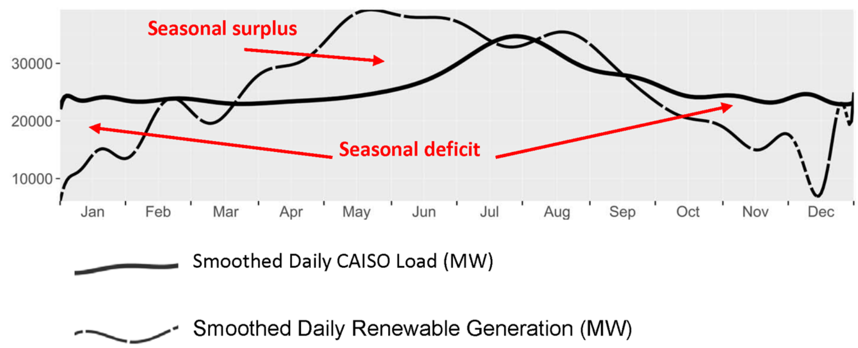

Figure 12

As you can see, there are multiple weeks of average surplus above demand during the summer months but substantial deficits September through February.

The consequence of this seasonal variation is that, even when California procures enough wind and solar output to meet total electricity demand on an ***annual average*** basis, ***roughly 27% of hours of the year cannot be served by wind and sun.*** This is shown in the "heat map" below, Figure 13, in which yellow, orange and red hours are unserved by variable wind and sun:

Percent of Hourly Load Served, Mixed 100% Wind and Solar Scenario

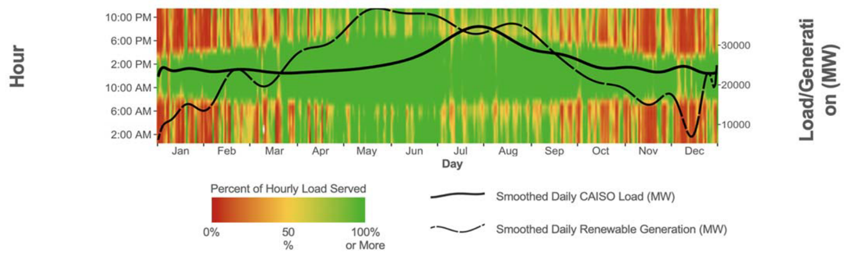

Figure 13

In theory, we could use battery storage to harvest surpluses and use them in deficit periods. But this is where cost comes in. The sheer amount of storage that must be built to capture maximum surplus, and then utilized infrequently, becomes cost prohibitive, even at very low storage costs.

In Figure 14, we see that the accumulated surplus during the year equals 35,946,633 MWh, or roughly 14% of the California's annual electric usage. To contain that much energy at peak storage time, you would need a storage system equivalent in instantaneous capacity larger than the generating capacity of the entire US electric grid.

Daily Renewable Energy Generation Surpluses and Deficits, Mixed Renewable Scenario

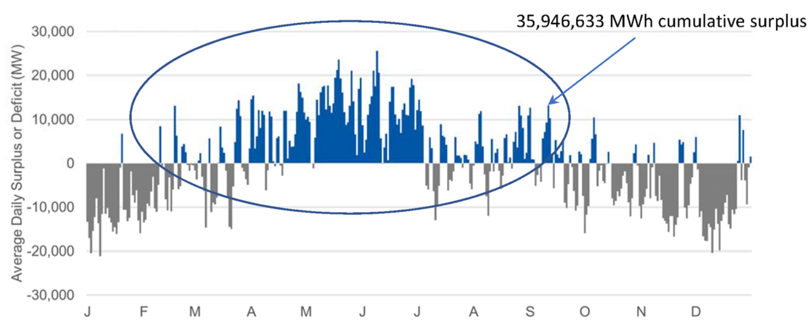

Figure 14: California surplus and deficit patterns under a 100% renewable energy scenario.

That much capacity will incur a very large capital expense. The US Department of Energy estimates the current cost of grid scale energy storage to be just under $500/kwh of capacity.[19] Let us assume we drop that cost by roughly 85% to $80/kwh. The total cost of such a battery storage system would be ***$2.9 trillion,*** or more than California's annual GDP of $2.7 trillion.

But that in some way understates the problem, because this storage capacity would be used at a very low rate – about 1% of capacity in an average year. That is because only a small amount of the storage capacity would be used regularly to balance daily variations in solar and wind output. Most of the storage capacity would need to be built to store peak seasonal surplus and thus only cycle seasonally. That means large capacity divided by little use, resulting in very large per unit costs for stored energy.

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[19] US EIA, "U.S. Battery Storage Market Trends "(May 2018)
https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage.pdf

The result, depicted in Figure 15 below, shows that the escalating costs of storage per unit output required, as wind and sun percentages become higher, drive very large system cost increases of roughly sevenfold as wind and sun go from 60% to 80% of energy supply, and roughly twenty four times as wind and sun provide all system energy.

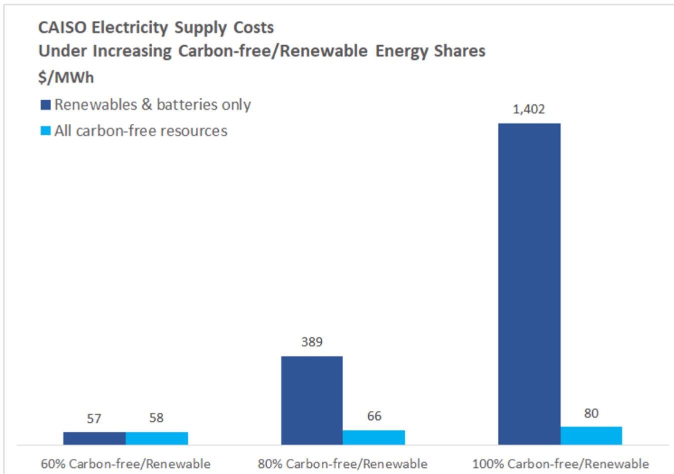
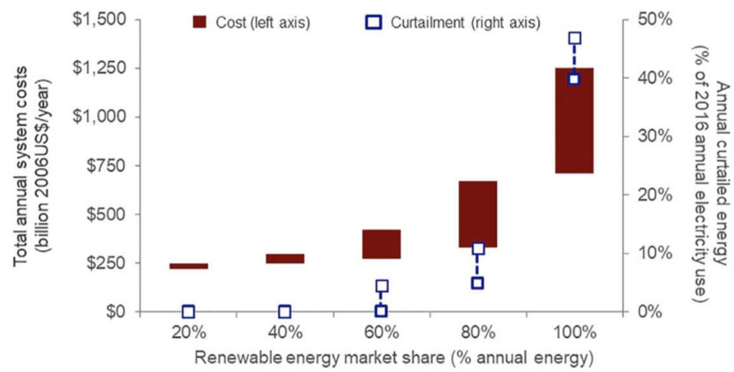


Figure 15. California energy systems costs with increasing shares of wind and solar, versus a mixed system including firm zero-carbon sources such as nuclear energy. Source: Clean Air Task Force calculated from CAISO data and aggressive assumptions on renewable energy and storage cost reductions.[20]

A similar cost escalation pattern has been seen in national studies, such as a recent one conducted by National Renewable Energy Laboratory analyst Bethany Frew, which also assumed a transcontinental electric grid and optimal demand response mechanisms (see Figure 16 below).

[20] The analysis assumes very aggressive further cost reductions in wind and solar energy compared to current projections by the US Energy Information Administration. Specifically, the analysis assumes that wind costs drop from $1,624 per kw to $1,000/kw and that solar PV drops from $1,969/kw to $700/kw.



Jenkins et al., Getting to Zero Carbon Emissions in the Electric Power Sector, Joule (2018), https://doi.org/ 10.1016/j.joule.2018.11.013, adapted from Frew, Bethany A., Jacobson, M. et al. "Flexibility mechanisms and pathways to a highly renewable US electricity future." *Energy* 101 (2016): 65-78.

Figure 16: Costs of supplying power in a national study of increasing shares of wind and solar. (Source: see Figure description above).

While these costs can be reduced by curtailing solar and wind output rather than storing all surplus electricity, note that that approach would leave the system in need of some other carbon free power to fill the void. As one can see from Figure 15 and 16, a system with substantial curtailment that provides 70-80% of energy from wind and sun rather than 100% still incurs steep costs – and still leaves the system in need of a back-filing zero carbon technology. Curtailment solves one problem, but creates another.

None of this analysis is to gainsay a substantial role – likely greater than 50%, or six times today's share – for wind and solar energy in cost-effectively achieving the electric system portion of the grid decarbonization challenge. And it is always possible that technological breakthroughs could occur that would make it possible to increase the percentage of economically affordable wind and solar to very high levels.[21] But supporting policies to bring other zero-carbon options to market will provide greater certainty of success.[22]

b. Technology diversity increases the chances of building the necessary infrastructure in time

Cost, however, is not the only issue. There is the question of whether we can achieve the necessary build-out by mid-century if we restrict ourselves just to one family of technology such as wind and solar, or nuclear, or carbon capture.

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[21] It is sometimes argued that "demand response," that is, the ability to curtail customer load, will alleviate the surplus and deficit problems outlined in this testimony. While this resource can be valuable, it is a question of scale and duration. Today, the California grid operator reports that the system has in place 350 MW of maximum load reduction/demand response — representing less than 1% of peak demand. See California ISO, 2018 Annual Report on Market Issues and Performance, http://www.caiso.com/Documents/2018AnnualReportonMarketIssuesandPerformance.pdf, pp. 29, 42. These agreements are generally understood to require interruptions for a few hours a few times a year. By contrast, as Figure 12 demonstrates, 100% wind and solar scenarios produce power deficits equal to as much as 75% of demand ***over many weeks***. It is not likely that California businesses, industries and consumers would effectively agree to multi-week and seasonal curtailment of demand, or that this would be good for the California economy if they did.

It also may be argued that interconnection of California to other control areas will alleviate the surplus and deficit problem. While greater interconnections can help at the margins, we must assume that other regions will be pursuing similar levels of decarbonization and are likely to adopt similar levels of variable energy. And wind and solar tends to be highly correlated on a daily and weekly across the nation. As a result, even with seamless national interconnection, as is assumed in the study referenced in Figure 16, substantial surplus and deficit problems are experienced at very high levels of wind and solar, with the resulting cost impacts shown in the figure.

[22] Zero carbon technology innovation policies range from R&D investments that focus on state of the art designs and construction methods, de-risking technologies for investors by supporting commercial demonstrations through purchase power agreements or contract for differences, driving costs down through deployment by performance-based tax incentives, and creating the infrastructure and regulatory pathways needed to build the new industry. See e.g., "Derisking Decarbonization: Making Green Energy Investments Blue Chip, Steyer Center for Energy Policy and Finance (2017) at: https://energy.stanford.edu/sites/g/files/sbiybj9971/f/stanfordcleanenergyfinanceframingdoc10-27_final.pdf; Sectoral policies that can help deploy zero-carbon energy technologies include "Clean Energy Standards" for the power sector and "Low Carbon Fuel Standards" for the transportation sector. Industrial decarbonization may require a suite of targeted policies depending on the emissions and process characteristics of the industry in question and may need to include boarder adjustment mechanisms. See: "Reducing CO2 Emissions from Heavy Industry, Briefing Paper #7" Grantham Institute for Climate Change (2012) at: https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Reducing-CO2-emissions-from-heavy-industry---Grantham-BP-7.pdf

For example, Figure 17 below depicts the amount of zero-carbon energy that would need to be added each year to the California grid to meet the state's mid-century zero-carbon target, compared to various historical addition rates. To achieve these targets on wind and solar alone would require California to deploy those sources at five times the best historic rate, every year for the next 25 years – the equivalent of nearly ten of the world's largest onshore or offshore windfarms ***every year***. In nuclear terms, this would amount to construction of more than one Diablo Canyon size plant (2256 MW) every year. Figure 18 shows similar national figures for various technologies.

Illustrative zero-carbon energy deployment rates to achieve California grid decarbonization target

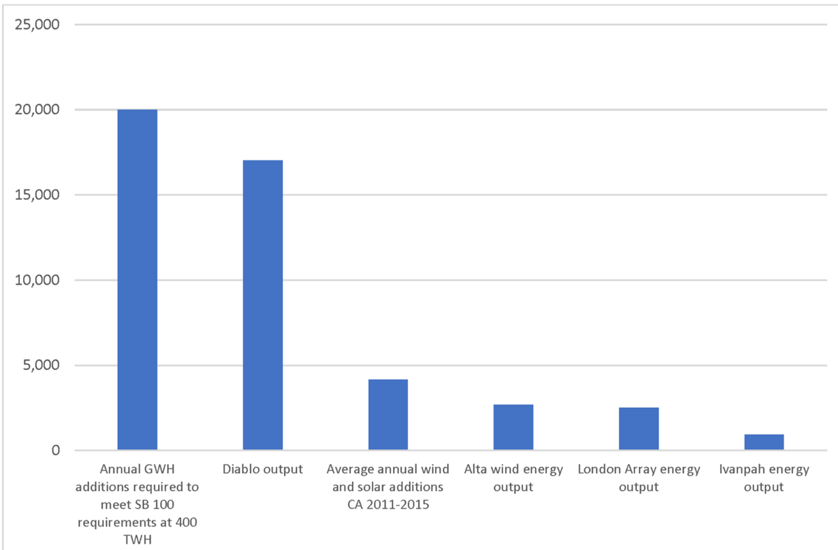

Figure 17: Annual zero-carbon energy deployment rates required to meet California's 2045 zero-carbon grid requirement starting in 2020, assuming increased electrification. It is assumed that all current zero-carbon energy infrastructure would need to eb replaced by midcentury. (Source: Clean Air Task Force calculated with historical data from published reports of the California Energy Commission, California PUC)

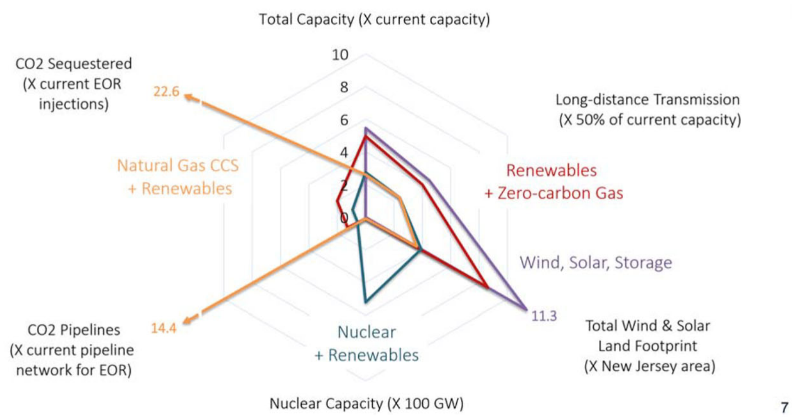

Figure 18: National buildout required for 100% carbon-free electricity, by technology. Source: J. Jenkins, *Critical bottlenecks in decarbonization of the U.S. electricity grid*, Jesse D. Jenkins, PhD, Princeton Rapid Switch Workshop (June 12, 2019), used by permission of author

By any measure, this is blistering and unprecedented pace of energy system buildout. It would be challenging enough to imagine achieving this with all of the available options. The difficulty increases as options are increasingly taken off the table.

The sheer engineering feat required is complicated further by public acceptance issues. Around the nation, and even, or especially, in more environmentally oriented states such as California, there have been substantial battles and delays over siting renewable energy infrastructure, and associated transmission.[23] Additional transmission needed to knit together diverse wind, sun and hydro resources are especially dramatic as renewable energy shares increase – requiring as much as a twenty-fold increase in US transmission capacity and interties for very high renewable energy scenarios, according to the National Renewable Energy Laboratory (see Figure 19 below). Just one such transmission line, in New England, has recently consumed roughly a decade of environmental debate, and is still not resolved.[24]

[23] See P. Field, et al, Resolving Land Use and Energy Conflicts (2018). https://www.cbsnews.com/news/new-york-wind-turbines-face-uphill-battle/ and https://friendsofmainesmountains.org/?category=Anti-Wind+Groups

[24] https://www.bostonglobe.com/metro/2018/11/22/plans-bring-hydropower-from-canada-cornerstone-state-energy-policy-faces-mounting-obstacles/3j6iBavrm4Libx8QdpX67M/story.html

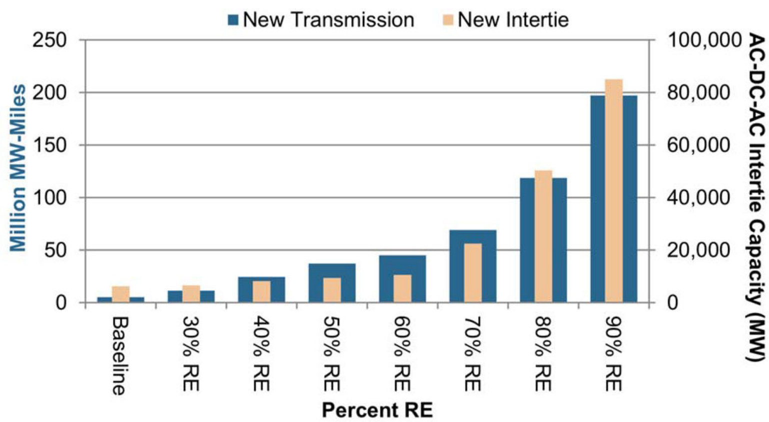

Figure 19: Transmission required for various levels of renewable energy deployment. Source: National Renewable Energy Laboratory, "Renewable Electricity Futures Study," Executive Summary, p. 26.

c. *Conclusion: Allow and Support Developing Firm Zero-carbon Electricity Options*

A diverse approach provides resiliency to the strategy by proving optionality in case insurmountable hurdles are faced in one pathway. As we have discussed, in addition to cost issues, a large build-out of wind and solar energy capacity, along with the substantial increase in transmission capacity that would be necessary to serve a wind- and sun-dominated system, may well face substantial and well organized opposition which has already emerged around relatively small scale proposals. Nuclear energy, while comprising the vast majority of the nation's zero-carbon energy today, has recently experienced cost overruns in the building of new first of a kind U.S. plants, and continues to face public concern around waste disposal and safety. The use of natural gas with carbon capture and careful methane emissions management, although based on well-demonstrated technologies, will likely face challenges from those opposed to the use of any fossil fuels for reasons including local health and environmental effects. The more options we have, the greater will be our chance of success, so Clean Air Task Force supports incentives and other policies to bring additional zero-carbon options to market.

3. ***Eliminating Super-Pollutants such as methane is a critical component of any plan to manage climate change***

I want to close with one last important point. True climate protection requires attention to carbon pollution *beyond* carbon dioxide. Methane, black carbon, hydrofluorocarbons (HFCs), and others represent highly-potent "super-pollutants" that, pound for pound, have a much greater warming impact than carbon dioxide.[25]

As noted above, one possible path to decarbonization of electric and fuels involves the use of natural gas, with carbon capture and sequestration. However, to play a role in climate mitigation, natural gas will need to virtually eliminate its collateral emissions of the super pollutant methane.

If released into the atmosphere (rather than combusted), methane—which is the primary component of natural gas—is a climate pollutant 87 times more powerful than CO_2 over a 20-year period and 36 times more powerful over a century time scale. Methane pollution is responsible for about a quarter of the warming we are currently experiencing. And concentrations of methane are surging in the atmosphere.[26] This methane rise has pushed the world off course of meeting the Paris Agreement goals.[27] If governments and companies fail to take action on non-CO_2 climate pollutants, it will be impossible to deeply decarbonize the world's energy systems.

Addressing methane emissions for the natural gas industry, where rampant and higher than reported methane leaks across the supply chain substantially erode the climate benefit of gas as compared to other fossil fuels, is of paramount importance.[28] According to the current best science, methane emissions from oil and gas in 2017 were more than 12 million metric tons,[29] or more than 1,000 million metric tons CO2-equivalent over a 20 year period. This is equivalent to the CO_2 emissions from more than 250 coal fired power plants.[30] According to the International Energy Agency (IEA), reducing fugitive methane emissions from the oil and gas sector is one of the highest-impact strategies to reduce global greenhouse gas emissions over

[25] Due to total volume of emissions, CO2 has the greatest total impact of average global temperatures. On a per ton basis, however, methane warms the atmosphere 28-36 times more than a ton of CO2 over a 100-year basis. Nitrous Oxide (N2O) has a GWP 265–298 times that of CO2 for a 100-year timescale. A number of gases, including chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6), are many thousands of times more potent per ton than CO2. See EPA (2017) https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

[26] NOAA. (2019). Annual Greenhouse Gas Index. Available at: https://www.esrl.noaa.gov/gmd/aggi/aggi.html

[27] Nisbet, E.G., Manning, M.R., Dlugokencky, et al. (2019). Very Strong Atmospheric Methane Growth in the 4 Years 2014–2017: Implications for the Paris Agreement. Global Biogeochemical Cycles, 33 (3), 318-342. https://doi.org/10.1029/2018GB006009

[28] R.A. Alvarez, D. Zavala-Araiza, D.R. Lyon, D.T. Allen, Z.R. Barkley, A.R. Brandt, *et al.* (2018). Assessment of methane emissions from the US oil and gas supply chain
Science 361 (6398), 186-188. DOI: 10.1126/science.aar7204.

[29] U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks, 2019. Chapter 3. Available at: https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-chapter-3-energy.pdf.
Alvarez, R.A., et al. (2018) "Assessment of methane emissions from the U.S. oil and gas supply chain," Science, Vol. 361, Issue 6398, pp. 186. Available at: https://science.sciencemag.org/content/361/6398/186.

[30] U.S. Environmental Protection Agency. Greenhouse Gases Equivalencies Calculator - Calculations and References. Available at: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#coalplant.

the next several years. Furthermore, the IEA has documented that low-cost technologies exist today to reduce emissions by 75 percent.[31]

Reducing flaring, which produces methane, black carbon, and carbon dioxide emissions alike, is another serious climate issue for the oil and gas sector. For example, flaring of natural gas in the Permian Basin is shooting up - it rose about 113 percent last year,[32] pushing the U.S. to number four globally for flaring, ahead of Nigeria.[33] In addition to wasting more than enough gas to supply all of Texas' home heating demand, flaring is a serious climate issue. Permian flaring pumps more CO_2 into the air than did any of the four Texas coal-fired power plants that retired in 2018, in addition to methane and black carbon. Flaring is also a source of local air pollution that can harm public health. Alternatives exist for most instances of wasteful and polluting flaring of natural gas, such as ensuring that gathering pipelines are present to take associated gas or otherwise capturing and beneficially using the gas.[34]

4. *Conclusion: building a 100% carbon-free energy economy by midcentury is tough but achievable*

Achieving a carbon-free energy and industrial system requires many things, some of which I have not discussed in detail in this testimony, such as electrification and energy efficiency. A full set of solution pathways can be thought of as a jigsaw puzzle that needs to be assembled, as shown in Figure 20 below.

[31] International Energy Agency. (2017). World Energy Outlook. Available at: https://www.iea.org/weo2017/.
[32] Rystad Energy. "Permian Natural Gas Flaring and Venting Reaching All-Time High," June 4, 2019. https://www.rystadenergy.com/newsevents/news/press-releases/Permian-natural-gas-flaring-and-venting-reaching-all-time-high/.
[33] The World Bank, Global Gas Flaring Reduction Partnership. "Top 30 flaring countries - table (2013-2018)." Available at: http://pubdocs.worldbank.org/en/603281560185748682/pdf/Gas-flaring-volumes-Top-30-countries-2014-2018.pdf.
[34] Carbon Limits. (2015). Putting Out the Fire: Reducing Flaring in Tight Oil Fields. Available at: https://www.catf.us/resource/putting-out-the-fire/.

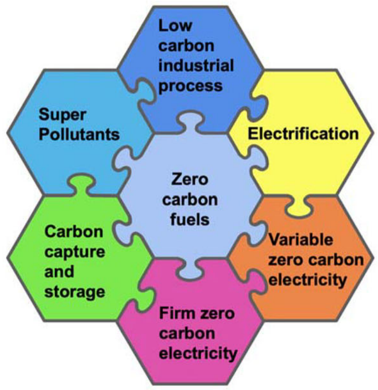

Figure 20: Decarbonizing the energy and industrial system will require assembling many different puzzle pieces.

While much attention has been given by policy-makers to zero-carbon electricity, and especially renewable energy, less attention has been paid to other critical components such as:

- Firm zero-carbon electricity
- Zero-carbon non-electric fuels
- Zero-carbon industrial processes
- Eliminating super pollutants such as methane if decarbonized fossil fuels are to play a role

There is an important role for both innovation and regulation to meet these challenges and create more affordable options for decarbonization. In this endeavor, there is a very important role for policy to play, and Congress and the states have already taken some important first steps. We need to quicken the pace and expand the technology and policy toolkit by combining economy wide emission targets or carbon pricing calibrated to achieve zero-emissions by midcentury[35] with innovation policies to bring additional, scalable zero-carbon technology options to market in time. Clean Air Task Force looks forward to working with this subcommittee and the Congress in that effort.

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[35] See: Phillips and Reilly, "Designing Successful Greenhouse Gas Emission Reduction Policies: A Primer for Policymakers – The Perfect or the Good?" at: https://globalchange.mit.edu/sites/default/files/MITJPSPGC_Rpt335.pdf

APPENDIX 1: The Potential Role of Bioenergy in Deep Decarbonization

- An energy technology can only play a leading role in decarbonization if it is massively scalable. Scalability presents unique challenges for bioenergy, however, because it competes for land with forests and other natural systems that are already sequestering carbon. The incremental climate benefits of using bioenergy—whether liquid biofuels or biomass-based power generation—tend to decrease (or disappear altogether) as bioenergy production increases and the supply of climate-beneficial biomass feedstocks is exhausted.

- The International Energy Agency has suggested that nearly 20% of projected global final energy demand in 2060 could be met by biomass-fueled power plants and other bioenergy systems,[36] but to meet that goal the global agricultural sector would have to roughly double the amount of plant matter it currently harvests.[37] Land use change of that magnitude would threaten natural ecosystems around the world and could drastically undermine forests' capacity to absorb CO2.[38]

- Large-scale production of liquid biofuel from conventional feedstocks like corn, soybean, canola, and oil palm presents a similar scalability challenge. The production of biofuel feedstocks drives up overall demand for both commodity crops and arable land. This demand in turn reshapes agricultural markets and encourages farmers—even those with no direct connection to biofuel—to convert previously uncultivated landscapes into cropland.[39] The conversion process (clearing, plowing, etc.) transfers soil and plant carbon into the atmosphere and creates a "carbon debt" that must be repaid before biofuels can actually reduce net greenhouse gas emissions.[40]

- Bioenergy is most likely to contribute to climate stabilization when it is derived from post-harvest waste feedstocks, like corn stover and some forestry residues, rather than conventional feedstocks. The use of waste feedstocks can be climate-beneficial because it creates a supply chain for bioenergy that does not encourage additional land conversion. In addition, waste feedstocks are no longer growing (and thus no longer sequestering carbon) and their embedded carbon will return to the atmosphere regardless of whether the waste is harvested and converted into energy or left in place to decompose.

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[36] International Energy Agency. 2017. Technology Roadmap: Delivering Sustainable Bioenergy, at 26 (https://www.ieabioenergy.com/wp-content/uploads/2017/11/Technology_Roadmap_Delivering_Sustainable_Bioenergy.pdf).
[37] Timothy Searchinger and Ralph Heimlich. 2015. Avoiding Bioenergy Competition for Food Crops and Land, at 13. Working Paper, Installment 9 of *Creating a Sustainable Food Future*. World Resources Institute (https://www.wri.org/publication/avoiding-bioenergy-competition-food-crops-and-land).
[38] Marshall Wise *et al*. 2009. Implications of Limiting CO2 Concentrations for Land Use and Energy, *Science* 324(1183):1183-1186; DOI: 10.1126/science.1168475.
[39] https://www.catf.us/wp-content/uploads/2019/07/BiofuelsMap.pdf
[40] Joseph Fargione *et al*. 2008. Land Clearing and the Biofuel Carbon Debt, *Science* 319(5867):1235-1238; DOI: 10.1126/science.1152747.

- The supply of economically-recoverable waste biomass is limited, so all such biomass should be used as strategically and efficiently as possible. For example, while multiple technological pathways can contribute to power sector decarbonization, there are few non-bioenergy pathways for decarbonizing the aviation sector. (Aside from biofuel, the most frequently mentioned option is synthetic jet fuel made from carbon that was removed from the atmosphere by direct air capture (DAC) systems.[41]) Accordingly, aviation fuel should be a high-priority use for any available climate-beneficial biomass feedstocks.

- In addition, as CCS systems make it increasingly possible to eliminate CO2 emissions from combustion processes, every bioenergy facility—whether existing or new—should eventually be required to install CCS, provided the facility can deliver its captured carbon to a sequestration site at a reasonable cost. Bioenergy with carbon capture and storage systems (BECCS) can potentially achieve negative CO2 emissions if they use climate-beneficial waste biomass feedstocks, but substantial research must be done to better understand the scale at which BECCS can be sustainably pursued.[42]

[41] *See* OECD, *ITF Transport Outlook 2019* at 142 (https://bit.ly/2YYq3ej).
[42] Christopher B. Field and Katharine. J. Mach, 2017. Rightsizing carbon dioxide removal, *Science* 356(6339):706-707; DOI: 10.1126/science.aam9726.

Mr. TONKO. Mr. Cohen, thank you.

And now Dr. Cleetus, you are recognized for five minutes, please.

STATEMENT OF RACHEL CLEETUS, Ph.D.

Dr. CLEETUS. Good morning, and thank you, Chairman Tonko, Ranking Member Shimkus, and members of the subcommittee for providing me the opportunity to testify here today.

My name is Rachel Cleetus and I am the policy director for the Climate and Energy program at the Union of Concerned Scientists.

The science is clear. We need to get to net zero carbon emissions by 2050 to help limit the risks of climate change including worsening flooding, heat waves, wildfires, and sea level rise.

Embracing a zero-carbon energy future would also be a boon for the economy and for public health. If we do this right, we can help ensure that all communities will benefit from this transition.

Reaching net zero emissions by 2050 will not be easy and it requires a sustained effort over decades. But a just and equitable low-carbon transition is both a necessary and achievable goal for the U.S.

The U.S. can and must play a leading role in the global efforts and right now we are far off track. The good news is that we have today many of the scalable technology solutions that we need to get on a path to net zero and others are clearly on the horizon—energy efficiency, renewable energy, electrifying energy end uses, and increasing carbon storage in lands and soils, for example.

The costs of wind, solar, and battery storage have been falling dramatically over the past decade. To decarbonize the power sector we need a diverse mix of zero-carbon technologies.

Most analyses including from UCS show that renewable electricity plays a dominant role in decarbonizing the power sector and, by extension, the rest of the economy.

Our analysis shows renewables reaching 70 to 80 percent of the generation mix by 2050 while conventional coal-fired power is phased out by 2030.

Natural gas with CCS and nuclear will likely need to be part of the mix, although their role is constrained by costs and we need to address associated safety, security, and social and environmental concerns.

Significant investments in infrastructure are needed for this transition. But the near-term public health benefits will be immense. As renewables are ramped up, we have many tools available to ensure reliable and affordable integration of this generation.

A key near-term challenge is how to avoid an over reliance on natural gas, which is still a fossil fuel and has associated methane leakage, methane being a potent heat-trapping gas.

The role of conventional natural gas must be contained within the next decade else we risk blowing past our climate goals or have billions of dollars in stranded assets.

Another near-term challenge highlighted in a 2018 UCS analysis—the nuclear power dilemma—is that more than one-third of existing U.S. nuclear plants face early retirement over the next decade and could be replaced by natural gas, risking a six percent rise in cumulative power sector emissions.

A national carbon price or low-carbon electricity standard combined with strong safety standards could help limit this risk. The transportation sector is the leading contributor to U.S. heat-trapping emissions today.

Therefore, cutting these emissions is essential, and that can be done by cleaning up vehicles and fuels through strong fuel economy and greenhouse gas emission standards and reducing the carbon content of fuels, and rapidly transitioning to electrification while investing in low-carbon mass transit.

The middle of the century can seem a long way off but the reality is we must implement policies right now to drive down emissions and avoid locking in long-lived carbon-intensive infrastructure.

We need a robust comprehensive economy wide suite of policies to scale up the many solutions we already have on hand, even as we invest in the research, development, and deployment of a portfolio of the next generation of zero-carbon technologies.

Congress is already considering many types of these policies, including proposals for an RES, a CES, 100 percent clean energy, a range of carbon pricing proposals, and tax credit extensions.

Done right, climate action can also help address long-standing inequities for low-income communities and communities of color that have borne a disproportionate burden of our dependence on fossil fuels, and we can also unleash the benefits of clean energy in these communities.

We must invest in just transition policies for fossil fuel-dependent workers and communities. It is now time for bold and comprehensive action.

Our choices today will determine the kind of climate future we leave our children and grandchildren. Last week, UCS released an analysis, "Killer Heat in the United States," that shows that if we fail to sharply curtail global heat-trapping emissions, rapid widespread increases in extreme heat are projected to occur across the country.

However, if we dramatically cut emissions we can greatly limit the intensity of the coming heat. Our nation just celebrated the 50th anniversary of humans landing on the Moon, an amazing testament to American vision, ingenuity, and courage. That is the can-do spirit we have to bring to the challenge before us today.

We are greatly encouraged by this committee's leadership, look forward to seeing Congress enact robust legislation, and we thank you, Chairmen Tonko, Rush, and Pallone, for the bold vision that you laid out yesterday.

[The prepared statement of Dr. Cleetus follows:]

Written Testimony of Dr. Rachel Cleetus, Policy Director, Climate and Energy Program Union of Concerned Scientists

"Building America's Clean Future: Pathways to Decarbonize the Economy"

The Subcommittee on Environment and Climate Change of the Committee on Energy and Commerce

July 24, 2019

Good morning and thank you, Chairman Tonko, Ranking Member Shimkus, and Members of the Subcommittee, for providing me the opportunity to testify here today. My name is Rachel Cleetus. I am the policy director and lead economist for the climate and energy program at the Union of Concerned Scientists.

Decarbonizing our economy is vital to help limit the risks of climate impacts, such as worsening heat waves of the kind that much of nation suffered through last week. Embracing a clean energy future would also be a boon for the economy and for public health. If we do this right, we can help ensure that *all* communities—especially fenceline communities that have borne a disproportionate burden of the health impacts of our dependence on fossil fuels—directly benefit from the transition to clean energy. We must also ensure a just transition for coal-dependent workers and communities.

This must ultimately be about a just and equitable socioeconomic transition, not simply technological changes. Decarbonizing the economy will not be easy and it will require a sustained effort over decades. But it is both a necessary and achievable goal for the US.

I'd like to start with a few **insights from the latest climate science**

The IPCC 1.5°C special report,[1] released last October, synthesized the latest science on the impacts of global warming of 1.5°C and 2°C and highlighted that impacts including heat waves, droughts, floods, wildfires, and ecosystem damages will worsen considerably, and often non-linearly, as temperatures rise.

The report also laid out GHG emissions pathways that would help limit temperature increase (see figure 1). To limit temperature increase to 1.5°C will require global net CO_2 emissions to be reduced by about 45% from 2010 levels by 2030, reaching net zero by 2050.[2] Deep cuts in non-CO_2 heat-trapping emissions, such as methane and nitrous oxide, will also be necessary. The

[1] Intergovernmental Panel on Climate Change (IPCC). 2018. Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emissions pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

[2] In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030, reaching net zero around 2050.

report points out that we will also need to deploy **so-called "negative emissions" options.**[3] These carbon dioxide removal technologies and practices include afforestation and reforestation; enhanced land management practices; direct air capture; and bioenergy with carbon capture and storage (BECCS).

The US Fourth National Climate Assessment —a quadrennial report mandated by Congress since 1990—was released last November.[4] Drafted by thirteen federal agencies and drawing on the best available science, the report emphasized that climate change is not about some distant future; communities around our nation are already coping with record-breaking heat, flooding, wildfires and accelerating sea level rise. The report's stark conclusion is that these climate-related impacts will only get worse and their costs will mount dramatically if carbon emissions continue unabated. Annual losses in some sectors are projected to exceed $100 billion by the end of the century and surpass the gross domestic product of many states.

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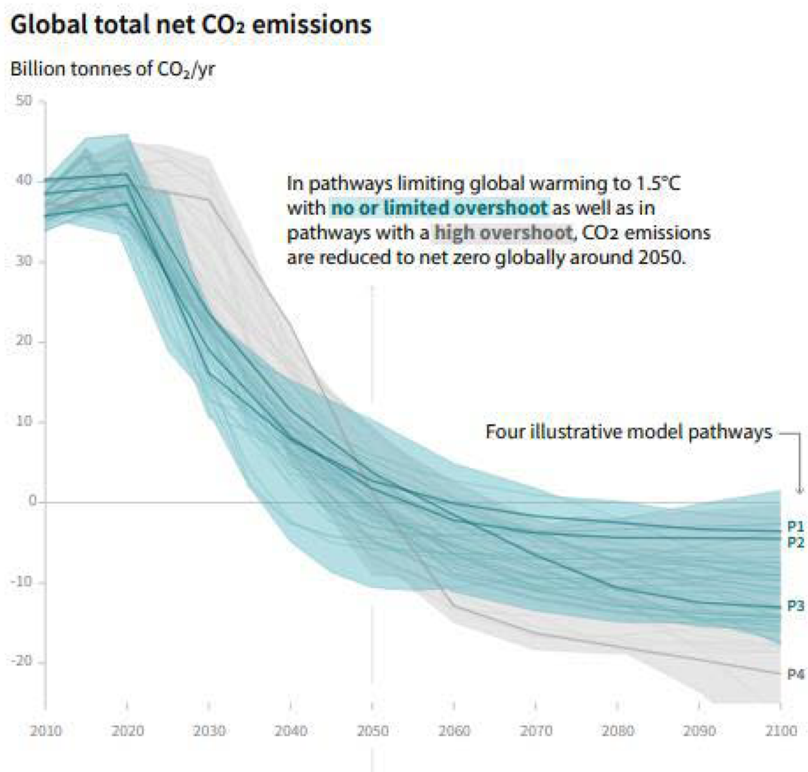
[3] All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of CDR on the order of 100–1000 GtCO2 over the 21st century.

[4] US Global Change Research Program (USGCRP). 2018. Fourth national climate assessment: Impacts, risks, and adaptation in the United States, volume 2. Washington, DC. Online at https:// nca2018.globalchange.gov.
See also: US Global Change Research Program (USGCRP). 2017. Fourth national climate assessment: Climate Science Special Report, volume 1. Washington, DC. Online at https://science2017.globalchange.gov/

Figure 1: IPCC modeled pathways for limiting temperature increase to 1.5C



So **where are we today relative to where we need to be?**

The science is clear: **we need to get to net zero global carbon emissions by 2050**.

The world's remaining carbon budget to stay below a 1.5ºC or 2ºC temperature increase is rapidly being depleted, and we're far off track of where we need to be as the 2018 UNEP Emissions Gap report points out.[5]

The US can and must play a leading role in charting the path to net zero emissions by 2050. In light of this, it's sobering to see EIA data showing that US energy-related carbon dioxide emissions were ***up*** 2.8% in 2018, the largest yearly increase since 2010. The *Annual Energy*

[5] https://www.unenvironment.org/resources/emissions-gap-report-2018

Outlook 2019 reference case projects they'll be roughly at current levels in 2050, which is a far cry from the deep reductions needed.[6]

The good news is that the costs of renewable energy are falling steeply. According to a recent report by Bloomberg New Energy Finance (BNEF), globally, the costs for onshore wind, solar photovoltaics and offshore wind have fallen by 49 percent, 84 percent and 56 percent respectively since 2010.[7] The costs of lithium ion batteries has decreased 76 percent since 2012. The DOE 2017 Wind Technologies Market report shows a reduction in the national average cost of wind purchasing power agreements (PPAs) in the U.S.—which represents the all-in costs of building and operating wind projects including both the capital cost reduction and increase in capacity factors—of 73% between 2009 and 2017.[8] Similarly, Lazard's annual levelized cost of energy analysis for the U.S. shows a continued decline in the costs of generating renewable electricity, especially utility-scale wind and solar, such that its costs are below or on par with conventional generation resources.[9]

The US is on track for 20 percent renewable electricity (hydro plus non-hydro renewables) by 2020, with about two-thirds of that coming from non-hydro renewables. In 2018, wind energy contributed 6.5% of the nation's electricity supply, more than 10% of total electricity generation in fourteen states, between 20% and 30% of the electricity in three states (North Dakota, South Dakota and Maine), and more than 30% in four states—Iowa, Kansas, Oklahoma, and South Dakota.[10,11] Texas leads the nation in installed wind power and jobs in the wind industry.[12] The latest data show that the US has just sped past the two million mark in solar photovoltaic systems.[13] Offshore wind is poised to take off, with new targets being set by multiple states, including Connecticut, Massachusetts, Maine, Maryland, New Jersey and New York and Virginia.[14] Several leading states, including California, Colorado, Hawaii, New Mexico, New York, and Washington have set ambitious targets for clean energy. States, cities, businesses and other sub-national entities are leading the way in eagerly embracing renewable energy because it makes smart economic sense and is good for the climate.[15]

We have at the ready many of the scalable technology solutions we need **to get on a path to net zero emissions by 2050**, including ramping up energy efficiency and renewable energy; electrifying many energy end-uses in the transportation, industrial and buildings sectors; and

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[6] https://www.eia.gov/outlooks/aeo/

[7] As measured by the levelized cost of electricity (LCOE) per megawatt-hour across 46 countries. Data from Bloomberg New Energy Finance. See https://about.bnef.com/blog/battery-powers-latest-plunge-costs-threatens-coal-gas/

[8] U.S. Department of Energy (DOE). 2018. Wind Technologies Market Report. Online at https://emp.lbl.gov/publications/2017-wind-technologies-market-report

[9] https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/

[10] U.S. Department of Energy (DOE). 2018.Wind Technologies Market Report. Online at https://emp.lbl.gov/publications/2017-wind-technologies-market-report

[11] https://nawindpower.com/awea-u-s-wind-grew-8-last-year-with-texas-leading-the-way

[12] https://nawindpower.com/awea-u-s-wind-grew-8-last-year-with-texas-leading-the-way

[13] https://www.woodmac.com/news/feature/the-united-states-surpasses-2-million-solar-installations/

[14] https://blog.ucsusa.org/john-rogers/raising-the-bar-on-offshore-wind-massachusetts-connecticut-new-jersey-new-york-maine-maryland-virginia

[15] More than 100 US cities have adopted 100% RE targets. See https://www.sierraclub.org/ready-for-100/commitments. 189 companies have made 100% RE commitments http://there100.org/companies

increasing carbon storage in lands and soils through better forest management, agricultural practices and soil management.

In the power sector, we need a diverse mix of low-carbon technologies. **Most analyses, including UCS', show renewable electricity playing a dominant role in decarbonizing the power sector**. This finding is robust across many studies including the 2016 US mid-century strategy for deep carbonization, the IPCC 1.5° C report, and the 2019 *350ppm Pathways for the US* study.[16] As renewables are ramped up, we have many tools available to ensure reliable and affordable integration of this generation, including investing in a modernized, more flexible electricity grid; investing in battery storage and new transmission capacity; having more geographical dispersion of renewable generation to take best advantage of plentiful resources nationwide; using the latest technologies to better schedule and forecast renewable generation; and implementing demand response and smart grid technologies.

The important thing to remember is that right now we are far from the high levels of renewables needed to reach net zero emissions. Renewables like wind and solar are the most cost-effective, near-term zero-carbon options, alongside energy efficiency. Many states are already demonstrating that policies to scale up renewables and energy efficiency are no-brainers. Our analysis shows that natural gas with CCS and nuclear will also likely need to be part of the mix, although their associated safety and social and environmental concerns must be addressed.

A 2016 UCS analysis shows that making deep cuts in power sector emissions, with high levels of electrification, is both feasible and affordable (especially when compared to the costs of runaway climate change).[17] We analyzed ways to cut US power sector carbon dioxide emissions by 90 percent or more by 2050, with four potential pathways characterized by a range of different technology cost and performance assumptions to capture uncertainties and to avoid being prescriptive. As a proxy for a robust policy, we used an escalating carbon price to drive emissions reductions.

We found that (see figure2):

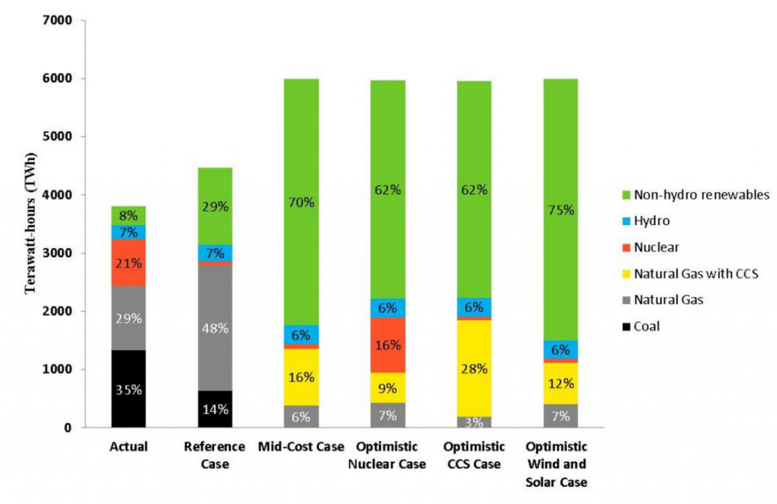
- **All scenarios showed a dramatic increase in renewable electricity resources,** with renewables reaching up to 80 percent of the generation mix by 2050 and on the order of 50 percent or more by 2030.
- **Conventional fossil-fired generation must be tightly curtailed**. By 2030, conventional coal-fired power is nearly phased-out. While conventional natural gas is still about a third of the generation mix in 2030 in most of our cases, it declines to 7 percent or lower by 2050.

[16] See https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf; https://www.ourchildrenstrust.org/350-ppm-pathways; and https://www.nrel.gov/docs/fy13osti/52409-ES.pdf; https://www.nrel.gov/docs/fy19osti/71913.pdf

[17] The US Power Sector in a Net Zero World. Online at https://www.ucsusa.org/sites/default/files/attach/2016/11/UCS-Deep-Decarbonization-working-paper.pdf

- **Natural gas with carbon capture and storage (CCS) will likely be needed.** This accounts for 9 to 16 percent of generation in three of our cases. In a fourth case, with optimistic assumptions for the costs of CCS, natural gas with CCS reached to 28 percent of generation by 2050.
- **Nuclear power's role is constrained by its costs**. In three out of four of our cases, nuclear generation stays relatively flat through 2030, and then declines quickly as existing nuclear plants are assumed to be retired when they reach 60 years. Only in one case, with optimistic assumptions about nuclear cost reductions and lifetime extensions, do we see a bigger role for nuclear power.
- **Significant investments are needed for a low carbon transition**. To shift generation to low and zero carbon resources and increase electrification of energy end uses, our analysis showed that power sector investments on the order of at least $250 billion per year are needed to bring on line the necessary clean energy resources and grid infrastructure. Additional investments would also be needed to build out infrastructure for electrification of other sectors, which our analysis was not able to account for.
- **The public health benefits of a low carbon electricity sector are huge.** The shift from fossil fuels to low-carbon electricity helps reduce CO_2 and co-pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), particulate matter and toxic pollutants like mercury. We quantified the monetary benefits of reductions in NOx, SO_2 and CO_2; all the low carbon pathways have cumulative benefits exceeding $270 billion through 2030, relative to the reference case, just from power sector emission reductions let alone emission reductions from electrification of other sectors.

Figure 2: US electricity generation mix in 2050 under four deep decarbonization scenarios



A key near-term challenge we must confront is how to **avoid an overreliance on natural gas.** Natural gas is still a fossil fuel and a coal-to-gas switch is not enough to limit emissions in line with our climate goals. While natural gas has helped accelerate a transition away from coal and can play an important role in helping integrate high levels of renewables, **to get to net zero, the role of conventional natural gas must be contained within the next decade**.[18] In 2015 for the first time CO_2 emissions economywide from natural gas surpassed CO_2 emissions from coal, and the AEO2019 Reference case projects that natural gas CO_2 emissions will continue increasing as natural gas use increases.[19] Further, the extraction, production, storage and distribution of natural gas leads to methane leakage, and methane is a much more potent heat-trapping gas than CO_2 over a 20-year horizon. Without strong safeguards in place, heat-trapping emissions from natural gas pose a grave threat to our climate goals. The rapid buildout of conventional natural gas infrastructure in the US currently is a deeply worrisome trend and raises the specter of billions of dollars in stranded assets if we are to meet our climate goals.

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[18] See https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/natural-gas-gamble-risky-bet-on-clean-energy-future and https://www.ucsusa.org/clean-energy/ca-and-western-states/turning-down-gas and https://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/climate-risks-natural-gas.pdf

[19] See https://www.eia.gov/todayinenergy/detail.php?id=38773

UCS analysis shows that to keep heat-trapping emissions down, we must limit conventional natural gas in the near term and begin a shift toward primarily natural gas with CCS by 2050. Innovative new technologies like Net Power's Allam Cycle design could also play a role.

A 2018 UCS analysis, *The Nuclear Power Dilemma: Declining Profits, Plant Closures, and the Threat of Rising Carbon Emissions*, highlights another near-term challenge.[20] We found that more than one-third of existing nuclear plants, representing 22 percent of total US nuclear capacity, are uneconomic or slated to close over the next decade. Without new policies, our analysis shows that if these and other marginally economic nuclear plants are closed before their operating licenses expire, the electricity would be replaced primarily with natural gas. If this occurs, cumulative carbon emissions from the US power sector could rise by as much as 6 percent at a time when we need to achieve deep cuts in emissions to limit the worst impacts of climate change. A national carbon price and/or low-carbon electricity standard (LCES) combined with strong safety standards would help preserve existing nuclear generation and help avoid an overreliance on natural gas.

The transportation sector is the leading contributor to US heat-trapping emissions today — producing nearly 30 percent of all US global warming emissions.[21] Light-duty vehicles—cars and light trucks—emit the most global warming emissions, nearly 60 percent, and medium- and heavy-duty trucks account for about a quarter of emissions in the transportation sector.[22] Rapid decarbonization of the transportation sector is essential and can be achieved by cleaning up the vehicles and fuels of today—through strong fuel economy and greenhouse gas emissions standards and reducing the carbon content of fuels—and rapidly transitioning to electrification.

Cleaning up Current Technologies: As we move toward increased transportation electrification, we must also ensure the vehicles of today emit fewer heat-trapping emissions and go further on a tank of gas. The Obama-era vehicle emissions and fuel economy standards, which, by 2030, are expected to reduce carbon dioxide emissions by around 500 million tons, are an important part of decarbonization,[23] and unfortunately the Trump Administration is seeking to roll them back.[24]

Transitioning to Electrification: To more rapidly reduce emissions in the sector, we must electrify our transportation system. Electric vehicles, on average, emit about half of the global warming emissions as a conventional car, which can significantly reduce emissions from cars and light trucks.[25] In the United States, for example, the average EV running on electricity will generate 3.3 tons fewer carbon dioxide equivalent emissions per year than an average car powered by gasoline[26], and EVs keep getting cleaner thanks due to the grid getting cleaner .[27] Medium and heavy-duty vehicles, which include buses, must also move toward electrification to help reduce both global warming emissions and criteria pollution. Electric buses, on average,

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[20] https://www.ucsusa.org/nuclear-power/cost-nuclear-power/retirements
[21] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[22] https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions
[23] https://www.ucsusa.org/clean-vehicles/fuel-efficiency/clean-car-standards.html
[24] https://blog.ucsusa.org/jonna-hamilton/congress-investigates-rollback-of-clean-car-standards
[25] https://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf
[26] https://blog.ucsusa.org/jonna-hamilton/will-congress-extend-ev-tax-credit
[27] https://blog.ucsusa.org/dave-reichmuth/new-data-show-electric-vehicles-continue-to-get-cleaner

produce less than half of the global warming pollution of buses running on diesel or natural gas.[28]

Making Fuels Cleaner: Finally, we must focus on making both conventional and alternative fuels cleaner. Low-carbon alternatives to gasoline are becoming more readily available and all fuels could make their operations more efficient and trap more heat-trapping gases in their processing.[29] We must make smart policy choices to ensure biofuels continue to get cleaner and hold oil companies accountable for extraction and refining practices that contribute to increased global warming pollution.[30]

While light-duty and medium-and heavy-duty vehicles are the largest contributors to US global warming emissions in the transportation sector, to get to net zero emissions reductions must be achieved for all sources, including aircraft, rail, and ships, through better fuel efficiency and cleaner fuels.

Done right, an economywide low-carbon energy transition **can also help address long-standing inequities for low-income communities and communities of color**—cutting the harmful pollution from fossil fuels that has disproportionately affected these communities and enabling them to partake in all the public health and economic advantages of a clean energy economy. For more, please refer to the *Equitable and Just National Climate Platform* which advances the goals of economic, racial, climate, and environmental justice to improve the public health and well-being of all communities, while tackling the climate crisis.[31]

The transition away from fossil fuels will disproportionately affect workers and communities dependent on them today. The reality is that coal is already on the decline due to market factors, primarily the low cost of natural gas. We're seeing record coal retirements year-on-year regardless of climate policies. So, **we must invest in just transition policies for fossil-dependent workers and communities**. This includes help with worker training, pensions and medical care for those at the end of their careers, direct investments to spur economic diversification in communities—all while engaging directly with communities so that they can shape their future. For a more detailed discussion of policies and resources needed to ensure that working people are front and center as we create a new economy, please see the BlueGreen Alliance's *Solidarity for Climate Action* platform.[32]

We need a robust suite of policies to drive a diverse set of zero-carbon solutions

The middle of the century can seem a long way off, but the reality is we have to implement policies right now to drive down emissions in line with an ambitious long-term deep decarbonization pathway and to avoid locking in long-lived carbon-intensive infrastructure. Getting to net zero will require a suite of policies across the economy, above and beyond business-as-usual. A comprehensive suite of policies to address emission reduction opportunities

[28] https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate
[29] https://www.ucsusa.org/clean-vehicles/clean-fuels/transportation-fuels-future
[30] https://www.ucsusa.org/clean-vehicles/clean-fuels/transportation-fuels-future
[31] See https://ajustclimate.org/
[32] See https://www.bluegreenalliance.org/work-issue/solidarity-for-climate-action/

throughout the economy should include: a price on carbon; a low-carbon electricity standard; tax incentives for zero-carbon technologies and energy storage; investments in a modern grid that can help integrate high levels of renewable energy; energy efficiency policies; policies to cut transportation sector emissions, including increasing fuel economy and heat-trapping emissions standards for vehicles, increased investments in low-carbon public transportation systems, such as rail systems; replacing gas-powered public bus fleets with electric bus fleets; incentivizing deployment of more electric vehicles, including through investments in charging infrastructure; and research on highly efficient conventional vehicle technologies, batteries for electric vehicles, cleaner fuels and emerging transportation technologies; Policies to cut emissions from the buildings and industrial sectors, including efficiency standards and electrification of heating, cooling, and industrial processes; Policies to increase carbon storage in vegetation and soils, including through climate-friendly agricultural and forest management practices; Investments in research, development, and deployment of new low-carbon energy technologies and practices; Measures to cut emissions of methane, nitrous oxide, and other major non-CO_2 heat-trapping emissions; and Policies to help least developed nations make a rapid transition to low-carbon economies. Investing in just and equitable policies to ensure that the benefits of a clean energy economy are shared by all is also critical.

We need to get moving today scaling up the many solutions we already have on hand, even as we invest in innovation to develop the next generation of zero-carbon technologies. It's a both/and proposition, not either/or.

A well-designed renewable electricity standard or low-carbon electricity standard or carbon price could go a long way toward driving more zero-carbon electricity onto the grid. UCS modeling of an escalating carbon price starting at $25/ton and a 95%-by-2050 LCES shows that both policies could achieve at least 50% renewable electricity by 2035. Similarly, a new UCS analysis shows that a national renewable electricity standard (RES) of 50% by 2035 would boost the economy, benefit consumers, and put the nation on a pathway to decarbonize the power sector by 2050.[33] Over the past decade, the renewable energy share of US electricity sales has grown by nearly 1% per year, on average, according to Energy Information Administration (EIA) data. A 50% RES would more than double that rate through 2035—an aggressive but achievable level consistent with the commitments adopted by leading states and recent analyses showing we can ramp-up to renewables to 80% of US electricity by 2050 and meet mid-century decarbonization goals.[34,35,36]

A robust and well-designed price on carbon could also raise revenues to address equity considerations related to climate change such as funding for economic investment in coal-dependent communities, including worker transition assistance; energy bill assistance for low-

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[33] https://www.ucsusa.org/sites/default/files/attach/2019/06/UCS-National-RES-Analysis-6-26-f.pdf
[34] https://www.nrel.gov/docs/fy19osti/71913.pdf
[35] https://blog.ucsusa.org/steve-clemmer/u-s-renewable-electricity-future-is-within-reach
[36] (see https://www.ucsusa.org/sites/default/files/attach/2016/11/UCS-Deep-Decarbonization-working-paper.pdf; https://blog.ucsusa.org/rachel-cleetus/seven-things-ipcc2018; and https://www.evolved.energy/single-post/2019/05/08/350-ppm-Pathways-for-the-United-States)

and fixed-income households; and investments in climate resilience especially targeted to frontline communities in the US and in developing nations.

It's important to recognize that, designed well, these three policies can help achieve similar emissions outcomes in the power sector. To get economywide emissions reductions, we need a suite of policies—there are no silver bullet solutions. For example, to enable the rapid build-out and integration of zero-carbon electricity resources, we also need to invest in modernizing our transmission grid. We also have to invest in research, development and deployment of a portfolio of the next generation of solutions—with the understanding that there are risks that some of these investments may not come to fruition in time or may come with serious social or environmental tradeoffs that must be carefully evaluated in consultation with affected stakeholders.

Congress is already considering these types of policies: For example, a recent renewable electricity standard proposal from Senator Udall focused on ramping up renewables through 2035; Senator Smith proposed a Clean Energy Standard, focused on decarbonizing the power sector by mid-century by deploying a suite of low and zero-carbon resources; there have also been a range of carbon pricing proposals introduced in Congress. The extension of tax credits for renewable energy, energy storage and electric vehicles are also under active consideration.

It's now time for bold and comprehensive action.

Our choices today will determine the kind of climate future we leave our children and grandchildren. Last week UCS released an analysis, *Killer Heat in the United States* that shows the rapid, widespread increases in extreme heat that are projected to occur across the country due to climate change, including conditions so extreme that a heat index cannot be measured.[37] Last week we also saw an incredibly widespread heatwave blanket much of the US and subject 290 million Americans to hazardous heat conditions over 3 days; at least 6 people died from exposure to this heat. What our work quite alarmingly shows is that those 3 days are nothing compared to the frequency of dangerous heat days we could face in the not-distant future.

Without global action to reduce heat-trapping emissions, by midcentury (2035-2065), the number of days per year when the heat index exceeds 105 degrees Fahrenheit would quadruple from historical levels (1970-2000) such that more than 150 of our larger cities across the country (cities with a population greater than 50,000) would experience an average of 30 or more days per year with a heat index above 105. That is compared to 3 such cities today. In that same mid-century timeframe, in the average year parts of Florida and Texas would experience more than 50 consecutive days with a heat index over 100F. By late century, areas that today are home to 180 million people (~60% of the current population) would experience >30 days / year on average with HI conditions >105 degrees (compared to <1 million people historically). By late century about 120 million people across the US—more than one-third of today's population—

[37] Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days. Online at https://www.ucsusa.org/global-warming/global-warming-impacts/killer-heat-in-united-states

would experience the equivalent of a week or more of conditions so hot they exceed the National Weather Service's current heat index scale.

The intensity of the coming heat depends heavily on how quickly we act now to reduce heat-trapping emissions. These results highlight **a stark choice: We can continue on our current path, where we fail to reduce emissions and extreme heat soars. Or we can take bold action *now* to dramatically reduce emissions and prevent the worst from becoming reality**.

Our nation just celebrated the 50th anniversary of humans landing on the moon, an amazing testament to American vision, ingenuity and courage. That's the can-do spirit we must bring to the challenge before us. We are greatly encouraged to see this committee take up the important topic of decarbonizing the US economy and look forward to seeing robust legislation enacted in Congress as soon as possible.

Mr. TONKO. Thank you, Dr. Cleetus.

That concludes witness opening statements. We now will move to member questions, each Member having five minutes to ask questions of our witnesses.

I will start by recognizing myself for five minutes.

A number of members have stated support for achieving economy wide net zero emissions by 2050 and, obviously, we want to get there sooner, if possible.

Now, my request here is to have each of you briefly give your perspective on this target. Is it ambitious? Is it aligned with the global scientific consensus? Is it achievable if we get started as soon as possible and how difficult will it be to achieve?

So Dr. Hausker, we will start with you, please.

Mr. HAUSKER. Thank you. I will preface my response by saying there are a lot of young people in the audience and, in fact, two of my daughters are behind me, and a niece, and we have a moral obligation to get to net zero by 2050 and leave them a climate that is not disrupted.

And, frankly, our generation has dithered for 30 years since I was a Senate staffer in 1988 and Jim Hansen testified before the Senate Energy Committee.

So, we need to get going on this. In terms of timing, it is a 30-year multi-sector transformation. I think the hearings that you are going to conduct over the next months will establish a good fact-based foundation for what can we do by 2030 realistically; what can we do by 2040 realistically.

Where can we deploy technologies fully commercial in a big way now versus what do we need to aim for by 2030, and I hinted at that in my testimony. We can go into more details.

But as several of us have noted, we have fully commercialized at low cost wind and solar. We can deploy that like crazy. We are on the edge of breakthroughs in CCS that will allow us to scale up in the 2020s to the kind of magnitudes that my colleague, Shannon, described.

There is longer-term research that we will need for things we need to deploy in the 2040s and beyond. So it is a mixture. Someone said there is no single policy. There is also no single technology that is going to do this.

I think all of us look forward to working with you in further hearings. Thank you.

Mr. TONKO. Thank you.

Ms. Angielski?

Ms. ANGIELSKI. So I will just build on what Dr. Hausker was just saying, that I think if we look to the lessons learned from the wind and solar industry, it took 25 years for that industry to actually commercialize, and with that 25 years there was significant investment by the U.S. in those technologies both for innovative research as well as tax credits and deployment policies as well as at the state and regional level to actually create markets for the sale of that electricity.

So, again, to my point, in my testimony was sustained and I think aggressive policy support—we are already there with carbon capture. It is not 25 years from now that we are talking about.

We are talking about another 10 years. We just need to build on the success of 45Q, continue to innovate, and do more projects.

Mr. TONKO. Thank you.

Mr. Cohen?

Mr. COHEN. Mr. Chairman, totally feasible and proof of concept—three examples in history. Sweden, Ontario, and France virtually decarbonized their grid in 20 years, OK, and they did it with a combination of technologies.

We can do it if we decide to.

Mr. TONKO. Thank you, and finally, Dr. Cleetus?

Dr. CLEETUS. Net zero by 2050 is an essential floor for an ambitious U.S. contribution to global efforts to limit temperature increase to 1.5 C.

The reality is we are hurtling to well over 3 C right now, and even right now at 1 C we are seeing terrible impacts across our nation—flooding, heat waves, droughts, sea level rise.

This is not a moment to lower the bar on ambition. We need to raise ambition as much as possible. It is not going to be easy. But the problem is not technology. I think we have all laid out that there are many pathways. We have the technologies available.

It is feasible. The challenge is political will. We are really encouraged to see this particular subcommittee take this issue seriously because it is political will that we need right now.

Mr. TONKO. Thank you. And two of the top line messages we are hearing today is that everyone believes in order to achieve this target we must, first, take an inclusive view of clean energy technologies, and, second, implement policies that result in emissions reductions from all sectors of the economy.

I am certain that everyone here has slightly different preferred pathways to decarbonization. But does everyone agree with these two overarching points and how important are they to keep in mind as we think through policy specifics?

Dr. Cleetus, why don't we start with you and work backward?

Dr. CLEETUS. We have the technologies available and the core of them is a zero-carbon technology transition in our energy sector.

Renewables will play a dominant role, as I said, but we will need to be—to be fully risk averse and be sure that we will hit our climate targets. We need to have a diverse mix of zero-carbon technologies on the table.

Mr. TONKO. Thank you.

Mr. Cohen?

Mr. COHEN. Completely agree, and I would just say there are two halves to this equation. There is innovation to get that diverse portfolio. But there is also market pull.

Innovation by itself is not going to get the pace we need.

Mr. TONKO. Thank you.

And Ms. Angielski?

Ms. ANGIELSKI. I would say that as it relates to carbon capture, we already have the 45Q incentives that actually put a price on capturing and storing CO2. So that is a good start and would encourage incentivizing more to that.

Mr. TONKO. OK. And, finally, Dr. Hausker?

Mr. HAUSKER. Your analogy is completely right. We need a broad portfolio. Just like in financial investments and just like if you are in Vegas—don't put all your chips on one or two slots.

Mr. TONKO. Thank you very much, and now I recognize Mr. Shimkus for five minutes. Our clock—we will keep you posted if it is offset.

Mr. SHIMKUS. I understand. That is right.

Thank you, Mr. Chairman.

For Ms. Angielski, in a February hearing this year on addressing climate change, Rick Powell of ClearPath testified, and I quote, "The expected emissions growth from developing Asian countries alone would offset a complete decarbonization of the U.S. economy by mid-century."

Do you agree with that statement?

Ms. ANGIELSKI. I will say that the IEA has actually just recently issued more analysis that came to the same conclusion.

Mr. SHIMKUS. In that same hearing, Ms. Angielski, we heard testimony that fossil energy will remain a major part of the energy mix in growing nations like India, Vietnam, Colombia, South Africa, because the sources are domestic, abundant, and affordable.

From a technological standpoint, what does it take for the United States to help these nations continue to use fossil energy and reduce emissions?

Ms. ANGIELSKI. So there are a variety of technology approaches that could be undertaken. Those countries are still emerging economies so they are looking for the lowest cost possible opportunity to generate energy.

In many cases that is with coal. And so if we—if they could adopt more highly-efficient coal systems and when we can actually export lower cost carbon capture technologies and help them implement it, I think those are the opportunities that we can evaluate as the infrastructure in those countries will be very young.

So they will have those assets on the ground that will continue to operate for many years.

Mr. SHIMKUS. Will it be easier for us to help them with a robust economy or a weak economy?

Ms. ANGIELSKI. From our perspective, a robust economy will also help us to invest in innovation that we need in order to export those technologies and let them help them to utilize them.

Mr. SHIMKUS. Thank you.

Let me go to Mr. Cohen. On your testimony on Page 4 it shows a chart—and I thought we were going to try to put it up on here so everyone can see it on the screen—about the change in primary energy demand globally.

The U.S. is in decline. So, this is the—I don't know if it is going to get put up, and I hope—anyway, you're going to have to turn around to see it, but you know it.

But this is a million tons of oil equivalency. So, this is the IEA's—International Energy Agency—world energy outlook, and -until, 2040 and it shows the U.S. would take a 30 million tons oil equivalent decline where you have those other countries at an increase.

I think we just have to have that in perspective. I think the technology debate we are having today is very, very important because we need to be the leader and then we can export to these areas that they are going to move in the fossil fuel sector regardless of what we do.

Mr. Cohen?

Mr. COHEN. Yes, and, Representative, I think the point of the visual was actually it is going to need to be cheap, too. Developing countries are likely not going to pay a big premium for clean energy.

So the commercialization process that we do in the U.S. just as we did for wind and solar to drive costs down is going to go viral around the world, hopefully.

Mr. SHIMKUS. Thank you.

And I will just end on this. The unspoken word, although it was mentioned once or twice, is nuclear. It has to be a huge part of the portfolio. You can't talk about France's decarbonizing without its 80 percent portfolio of nuclear generation.

So, we need to work on that from our side, too, because we don't have a very consistent message to nuclear power in our country right now.

With that, Madam Chairman, I will yield back.

Ms. CLARKE [presiding]. Thank you.

The Chair now recognizes Mr. Pallone, full committee chairman, for five minutes to ask questions.

Mr. PALLONE. Thank you.

I wanted to talk a little bit about a technology neutral approach and also about natural gas. So yesterday the committee announced our intention, as you know, to chart a legislative a path towards a 100 percent clean economy, defined as net zero greenhouse gas emissions by 2050 and this is the target that the science says we must achieve if we are to limit warming to 1.5 degrees Celsius, avoiding the worst effects of climate change. And I know this is going to be a challenge but I think we can do it.

So let me start out on the technology neutral approach.

Dr. Hausker, you covered this in your testimony. Could you just explain why we should take a technology neutral approach to comprehensive climate policy?

Mr. HAUSKER. Yes. I think I will contrast it to there are some very serious people in the climate policy community who would like us to commit to 100 percent renewable energy as the solution, and then there is another group of equally serious people that say we should take a technology neutral approach, leaving the door open to things like nuclear and carbon capture on fossil fuels.

And the reason that I am in the camp of a technology neutral approach is that there are likely—we are likely to hit some obstacles if we try to lock in just a narrow set of technologies—renewables only.

It may be possible to supply all the world's needs with 100 percent renewable. One can't predict the future with certainty. But it is much less risky to invest in multiple technologies that can get us there as long as we manage all of the related environmental issues.

There is not only just CO2 but there are other issues related to fossil fuel extraction and combustion. With nuclear we need to make sure the plants are safe and that we can safely store the waste and control proliferation problems.

But, particularly, it will be very difficult to keep costs affordable and go to 100 percent renewables. We can go deeper into that if the committee wishes.

Mr. PALLONE. All right. I wanted to ask some of the others about this too but I have to get to natural gas. So if anyone else wants to briefly comment and answer the question about the technology neutral approach.

Mr. Cohen?

Mr. COHEN. Yes. May I just add a couple points to Karl's comment?

First of all, as I set out in my testimony, I would go a little farther and say the vast majority of studies that have looked at the electricity sector have concluded that firm zero-carbon energy, you know, nonweather dependent, whether it is nuclear or carbon capture, is going to bring costs down and, you know, there are some outlier studies that suggest it. But I would say that that is a distinct minority of the studies out there.

Second point is renewables are great for electricity. Not entirely clear how you decarbonize cement, steel, or how you decarbonize all heavy freight with renewable energy.

So there is some—even if you could do 100 percent electricity—100 percent renewable on the electricity grid, there are other sectors to worry about.

Mr. PALLONE. All right. I am going to move on because I want to ask about the role of natural gas.

Dr. Cleetus, in your testimony you discuss the near-term challenge of avoiding an over reliance on natural gas. Could you explain your concern with this scenario and why it should be a problem—why it could be a problem for meeting our 100 by '50 goal?

Dr. CLEETUS. So the reality is right now in the U.S. we are seeing a tremendous build out of natural gas infrastructure. It is one of the drivers for the significant amounts of coal retirements we have seen. It has helped integrate renewables online. So there is definitely a role for natural gas.

The problem is that if we look ahead and we look at the fact that natural gas is still a fossil fuel, comes with CO2 emissions, a coal-to-gas switch will just not be enough to meet our climate goals.

And further compounding that problem is that we have these methane emissions from natural gas that are leaking—very potent greenhouse gas heat-trapping emission—and that could mean that just by natural gas being built out in this way—conventional natural gas—we could completely blow past our climate goals. We have to get our arms around this problem and limit this unmitigated build out of conventional natural gas.

Natural gas with CCS in our modelling shows up as it could be a contributor to a net zero world. That is the way in which we need to be leaning.

Mr. PALLONE. All right. I appreciate it.

Mr. Cohen, you touch on this issue in your testimony and you stress the importance of eliminating super pollutants such as methane. Do you want to elaborate on the importance of addressing the methane emissions in order to meet our 100 by '50 target?

Mr. COHEN. As I set out in the testimony, the problem with methane is that it is 87 times more powerful as a warming pollutant per unit than a CO2.

So very important—if we use natural gas and we decarbonize it with CCS but we leave the methane out there, we are not doing ourselves any favors from a climate standpoint.

The agenda before us is pretty straightforward. First of all, the EPA has regulated or has regulation in place to deal with new sources of natural gas. But that is only about 20 percent of the total.

We need to extend those regulations to cover existing wells. We also need a lot of RD&D to make—really button up that system and make it zero methane leakage, and there are many things we could talk about in future hearings that would do that.

Mr. PALLONE. I thank you. I thank all of our witnesses.

Ms. CLARKE. Colleagues, I just wanted to bring to the attention of the room that, unfortunately, we are having a little difficulty with our clock system.

So we have come up with a solution. We are using stopwatches back here. So, you are going to have to trust me that your five minutes are up.

Having said that, I now recognize Mr. Long.

Mr. LONG. Thank you. Yes, I was wondering about that clock situation. We can watch it here and it will go up and it will go down, and I didn't know what was possessing it.

But I am from Springfield, Missouri, and in Springfield, Missouri, back in the 1950s there was a nationwide the first country television show called "Ozark Jubilee" and on "Ozark Jubilee" stars would come in from all around the country. Red Foley made it big there, Porter Wagoner, on and on.

There is a little restaurant, Aunt Martha's Pancake House, because Aunt Martha performed on the Jubilee so she opened a pancake house, and this guy came to town and he couldn't make it on the Jubilee and he said, well, I will prove to them I can make it.

So he went over to Aunt Martha's, got a job washing dishes for quite some time and every week he would go back and audition, and they said, you have no talent.

So Willie Nelson left town and but Aunt Martha's remained, and during the time when we went to no smoking in Springfield, Missouri, the people that owned Aunt Martha's at that time weren't real fond of the new no smoking policy.

And so you would go in there and you would sit at a nonsmoking table, which most people like. The table next to you was smoking. The next one was nonsmoking. The next one was smoking. Nonsmoking. So it sort of defeated the purpose.

And I use that analogy to think—if you have travelled to China, if you have travelled to India, those are the type of things that complicate this whole climate change and trying to clean up the environment, because if you are clean at your table and not smoking it really doesn't do you much good when the next table is allowed to smoke and put out those kind of pollutants.

Mr. Cohen, I would like to focus on how we can reduce carbon dioxide emissions while keep energy and commodity prices low, particularly in rural and agricultural communities like those I represent.

In my home state of Missouri, coal-fired power plants provide 73 percent of our electricity—provided 73 percent of our electricity in 2018. This is an improvement from 2017 where coal produced 81 percent of our electricity, so going from 81 to 73 is moving in the right direction.

But as we talk about decarbonizing the whole economy while electric generation seemingly gets most of the attention, it only makes up, as has been mentioned here today, about 40 percent of the emissions we produce.

You say in your testimony that a carbon-free energy system requires essentially zeroing out energy-related greenhouse emissions from all sectors of the economy by 2050.

When you think about agriculture, do we currently have the technology to decarbonize the agricultural industry while continuing to produce and move goods to market without harming consumers?

I can see electric cars. I can see Volts. I can see Teslas. I can see electric cars moving up and down the interstate system. But as I am driving down that interstate system and I look out to the fields and the massive tractors and horsepower required, is that practical and where are we on that?

Mr. COHEN. Let me just caveat and say—I probably should have said at the outset—I am really much more expert on the energy system and agricultural is not my field. But let me just make one—give you one example.

So right now actually the agriculture uses ammonia fuel for farm equipment on quite an extensive basis. That is quite interesting because ammonia is potentially a zero-carbon or zero emitting fuel.

It is made from hydrogen and, you know, combined with nitrogen and you have got ammonia, and it is used for fertilizer, obviously, but also for—so we actually have an example of, essentially, a zero-carbon combusted zero-carbon fuel in the agricultural sector. Expanding that would be a really big step throughout the agricultural sector and actually throughout the economy.

As far as other—I think other people on the panel are more expert on soil management and cropping and low-carbon agriculture and methane capture from livestock and so forth.

But I do think that there are certainly areas to go in but I, honestly, am not deep on that. My focus is on energy.

Mr. LONG. Let me ask Dr. Hausker—the same question as far as the practicality of electrification of the agricultural enterprise, you mentioned low carbon and zero carbon in your opening comments. Can you kind of explain how—what that would look like in the agricultural community?

Mr. HAUSKER. Sure. I think you are putting your finger on some end uses—some sectors that will be the more difficult to decarbonize.

Some agricultural applications of energy, heavy duty transport, and jet fuel will all be more challenging to find solutions to than the other examples you cite, like we know how to have electric heat pumps for buildings, electric water heaters, electric cars.

That is kind of the low-hanging fruit. That seems ready for commercialization. But there are things—here is why we need an innovation agenda, building off of some things that my colleague, Armond said.

We know how to make synthetic methane, and one of the feedstocks could be CO2 that we capture through other uses. We know how to use ammonia potentially as a fuel. We ultimately can make hydrogen as a fuel, and all of these have potential applications in those more difficult to decarbonize end uses like you cite.

Mr. LONG. We have talked a lot about carbon capture on this committee over the years and it looked like it was pretty slow to get to first base. But now that it is starting to move, can you kind of bring us up to date on where we are on carbon capture and what that looks like, going forward?

Mr. HAUSKER. Yes. I will give a quick answer and then I want to defer to my colleague, Shannon, who, I think, has deeper knowledge on this.

But you have heard a couple of examples here of plants that are already in operation. We know that the oil and gas industry has injected CO2 into old oil and gas fields for decades and safely stored that.

We know that we have plants being demonstrated now and we know that we have a very promising demonstration of natural gas with CCS at the 50 megawatt demonstration level in Texas, and that is the Net Power example that I cited.

So we are, I think, at the cusp of really commercializing CCS and let me——

Ms. CLARKE. The gentleman's time has actually expired. We will probably pick up on those questions as we move along.

And I know recognize myself, the gentle lady from New York, for my questions for five minutes at this time.

And I want to thank Chairman Tonko and Ranking Member Shimkus for convening this extremely important hearing on what we can and must do across our entire economy to cut greenhouse gas emissions and put an end to the environmental pollution that is harming our communities and driving our climate crisis.

Thank you as well to you, our witnesses, for being here today. The world right now is facing a climate emergency. According to the Intergovernmental Panel on Climate Change, we have until the year 2030 to make rapid, far-reaching, and unprecedented changes to limit greenhouse gas emissions and to avoid the worst effects of climate change by 2050.

But we don't need to wait until 2050 to feel the effects of climate change. We don't even need to wait until 2030. The climate crisis is happening right now and communities across our nation are already suffering the consequences, especially our low-income communities and communities of color, who are on the front lines of this crisis.

In my home city of Brooklyn, New York, thousands of families were displaced when Superstorm Sandy struck our communities back in 2012, flooding entire neighborhoods and critically damaging our subway systems and other critical infrastructure.

Even today, many families still have been unable to come back to their homes and just this weekend, like Chairman Pallone in my district and neighboring communities in Brooklyn, we faced blackouts due to the prolonged overheating, if you will, extreme temperatures that have hit the Northeast region of the United States, driving a number of communities to really suffer as a result of these blackouts. Overwhelmed infrastructure, overwhelmed energy grids, old infrastructure—we know that if we really put our minds to it we can address.

The key to avoiding the greatest human and economic costs of climate crisis, as my city has learned, is to take action before it is too late.

Earlier this year, New York City passed its own Green New Deal, if you will, committing $14 billion in clean investments that will safeguard our communities and spur thousands of good-paying jobs.

And New York City is not alone. Just last week, New York State passed the most ambitious state-level climate legislation in the nation with the goal of decreasing our economy-wide greenhouse gas emissions by 85 percent by the year 2050. We are trying to do our part.

So I applaud these recent achievements in New York City and New York State, and I look forward to working with my colleagues on this committee to accomplish similar climate action on the Federal level.

Having said that, my first question is to Mr. Cohen. According to the EPA, emissions from transportation have actually been increasing since 2012. In fact, as of 2016, the transportation sector has officially become the single largest source of greenhouse gas emissions in the United States.

I find this deeply concerning. Do you share my concern? What do you believe are the greatest challenges and opportunities for vehicle electrification in the United States and what can Congress do to help encourage this transition?

Mr. COHEN. So yes, it is a concern and, in fact, as electric power gets cleaner, obviously, the transportation wedge will be comparatively larger.

So there are really two paths, right. There is electrification and then clean up the grid, and then there is some kind of fuel that you drop into a combustion engine, and I think we are going to need both.

So my top line would be something like a low-carbon fuel standard that requires increasing shares of zero-carbon fuel for transportation throughout the country over time—give the industry time to adapt—and then put in the necessary RD&D dollars to make sure that those zero-carbon fuels are available.

I think it could be technology neutral. It could be electricity. It could be hydrogen. It could be ammonia. It could be biofuels that are climate beneficial.

But we need a market driver to make that happen. We can't conserve our way out of the transportation problem. Efficiency is good but it is not going to get us to zero.

Ms. CLARKE. It is my opinion that we don't simply need to build a clean future. Instead, we need to build a clean equitable future.

New York State recently signed climate legislation attempts to move towards this goal by prioritizing new investments in disadvantaged communities and also by ensuring that no solutions are implemented which might increase the burden on low-income communities or communities of color.

Dr. Cleetus, in your testimony today, you talked about the need for just and equitable socioeconomic transition. Can you speak a little more about what this means in terms of decarbonizing the economy and how do we ensure this massive transformation of the economy benefits all communities and does not continue to negatively impact low income communities and communities of color?

Dr. CLEETUS. We have an opportunity here as we address the climate crisis to make sure that we do it in a just and equitable way. In fact, that is the best way to address the climate crisis.

Just last week, there was an equitable and just national climate platform that was released by a number of environmental justice and national environmental groups.

It lays out some core principles that point out that as we address climate change we can cut and we should cut pollution directly in communities that have borne a disproportionate burden of our dependence on fossil fuels.

Fence-line communities that are in the path of the smokestacks are seeing vehicle emissions in their communities that have led to high asthma rates and other cancers in their communities.

So it is really, really fundamental and important that we aren't just talking about cutting emissions and technology changes but deep social economic changes that move us towards a more just society and address longstanding inequities.

It is a big opportunity. There are lots of twofers. We can build low-carbon and climate-resilient infrastructure in these communities that will help protect people, clean up the air and water and make sure that they are full participants in a clean energy economy.

Ms. CLARKE. Thank you. I yield back my time.

And now the Chair recognizes the ranking member of the full committee, Mr. Walden, for five minutes to ask questions.

Mr. WALDEN. Thank you, Madam Chair, and I want to thank all of our witnesses. We have two hearings going on simultaneously. So some of us have to bounce back and forth.

Ms. Angielski, Republicans have been briefed by the Department of Energy on some of the exciting new technologies that are there to extract carbon from the atmosphere including one that would be a simple membrane to potentially remove carbon dioxide from coal emissions.

What is necessary to accelerate development of those technologies and what do you think the impact could be of them?

Ms. ANGIELSKI. So I think from an innovation standpoint I think that we could look at increasing some of the budgets that the Department of Energy currently receives for carbon capture.

That would be on the research side. I think we also need larger budgets to accommodate and support the scale up and testing of those technologies at a commercial scale.

We need to do some pilot work. We do have something called the National Carbon Capture Center that is operated by Southern Company and supported by DOE where we can test some of those technologies at a smaller scale.

But we don't have that sort of mid-level scale testing capability. And so a lot of these technologies that are individual technologies are looking to partner at power plant sites.

So if we were to have more test facilities and the Federal investment going into those scale-up opportunities, I think that we could really see some of these innovative technologies being accelerated in terms of commercialization.

And I also just want to mention that there is one that is already operating on natural gas right now called NetPower that Karl Hausker referenced. But it is at that scale and size of testing that we really need to understand how these technologies are going to operate to be able to benefit from them.

Mr. WALDEN. Can I ask each of you, and because of limited time we'll try and keep this short, but do you all believe that nuclear power is a key part of the solution here?

Just sort of yes or no, if you could.

Mr. HAUSKER. I will say yes. Both the existing plants have a role to play and I think with sufficient RD&D we could probably bring a new generation——

Mr. WALDEN. You reference NuScale. Yes.

Ms. ANGIELSKI. Members of CURC look at the diverse generation portfolio so that includes nuclear.

Mr. WALDEN. Nuclear. And Mr. Cohen?

Mr. COHEN. Yes. But there is a lot of work to do.

Mr. WALDEN. Right. Dr. Cleetus?

Dr. CLEETUS. Nuclear power can play a role but UCS has long been a nuclear safety watchdog and safety must be central——

Mr. WALDEN. Of course.

Dr. CLEETUS [continuing]. To how we deploy nuclear power.

Mr. WALDEN. Right. Of course.

I want to go, too, to the fleet because transportation is such a big part of this. I think we are making gains on the power generation side and I hope, you know, we are all hopeful innovation will lead there.

We have manufacturing issues to deal with on emissions. But what about the transportation fleet? And there are various proposals out there. Some call for, you know, raising the costs of driving, basically, with higher fuel taxes and all.

Do you all support that sort of concept and, if so, what do you think that number needs to be on a per gallon cost?

Mr. HAUSKER. If I can take the question a slightly different direction, which is, more broadly speaking, we need some kind of price on carbon as a sort of foundational policy to shift to the economy.

That can be done through fees and taxes. That can be done through cap and trade. There is a very rich debate out there.

Mr. WALDEN. Right.

Mr. HAUSKER. But we need a price on carbon.

Mr. WALDEN. All right.

I just want to get each of you, briefly. I have got another question after that.

Ms. ANGIELSKI. I won't comment on transportation fuels. It's just not within the mission.

Mr. WALDEN. Not your deal. OK.

Mr. Cohen?

Mr. COHEN. I would take a much more innovation-focused approach. I would sort of see if we can push technologies through the pipeline like I discussed to get the costs down so that the delta isn't as big.

I think some evidence is that even if you had a fairly high carbon tax the economy probably wouldn't too much——

Mr. WALDEN. So, you are not advocating for that——

Mr. COHEN. Not——

Mr. WALDEN [continuing]. For the vehicle fleet.

Dr. Cleetus?

Dr. CLEETUS. To decarbonize the transportation sector we have got to address the vehicles, we have got to address the fuels, and we have got to address the infrastructure, including electrification infrastructure as well as building out mass transit.

A carbon price alone will not help accomplish those goals. So we do need fuel economy standards, greenhouse gas standards. We need electric vehicle tax incentives. We need to be investing in the kind of infrastructure that'll help electrify as much of the electric fleet as possible.

Mr. WALDEN. I want to ask about the agricultural sector as well. Some of the recommendations that have been put forth by some groups basically call for the elimination of cattle grazing because of cattle production.

Do you all support that concept? I have only got 22 seconds for all of you so——

Mr. HAUSKER. I don't think we should be just eliminating classes of food. There are other things we can do to be smarter.

Mr. WALDEN. All right.

Ms. ANGIELSKI. I am with CURC so I am going to pass.

Mr. WALDEN. All right.

Mr. COHEN. I am going to pass on that. We haven't looked at that deeply.

Mr. WALDEN. All right.

Dr. CLEETUS. There are serious proposals for how we can cut emissions and how the agricultural sector can play a big role including through—for better soil management and agricultural practices to store carbon better in soils.

Mr. WALDEN. What about cattle specific?

Dr. CLEETUS. I don't think that is actually a serious proposal. I think there are serious proposals out there and we should certainly explore them to help limit these emissions if we are serious about tackling climate change.

Mr. WALDEN. Thank you, Doctor.

Thank you, Madam Chair.

Ms. CLARKE. The Chair recognizes Mr. Peters for five minutes to ask his questions at this time.

Mr. PETERS. Thank you, Madam Chair.

I want to say, first of all, I am very happy to have this hearing. I have been among a number of people who have been frustrated with the dominance of politics and the lack of solutions.

Today it looks like we are actually having a discussion about a range of solutions to deal with this issue. I think it couldn't come soon enough.

Also, I want to acknowledge that I think that the concerns raised by my Republican colleagues about foreign policy in India and China are 100 percent legitimate.

We ought to be working on what we can do as a matter of foreign policy to discourage the implementation of the use of coal, in particular, but to encourage the use of renewables so that they come along with what we discover here.

And I want to talk about two things. I am emphasizing, just briefly, on one is super pollutants. I mean, I think that one of the things that we have talked about here is that we know natural gas burns cleaner than coal.

That is seen as an advantage. But if we lose the benefit because of methane emissions, I think, you know, we are hurting ourselves.

And the opportunity in methane emissions and with all these short-lived super pollutants is that they are short-lived so that if you can keep them from getting into the atmosphere they don't persist like carbon dioxide.

You can have a really quick impact—relatively quick impact on the rate of climate change. And so I think that is something that deserves a lot of emphasis here.

But I want to talk a little bit about negative emissions technologies since I think almost all of you addressed that and it hasn't gotten a lot of attention.

I address the first question to Mr. Cohen. One of the concerns about carbon capture technologies is that it is too expensive to implement on a large scale and, moreover, that the technology as it exists today doesn't work as advertised.

Ms. Angielski talked about this a little bit. But can you discuss what carbon capture activities are currently taking place in the United States and what both industry and government are doing to bring down the costs of those carbon capture projects?

Mr. COHEN. All right. I have global numbers, which is that globally there are now 18 fully commercial carbon capture units on industry and power around the world. I believe five are under construction and some 30 are—I am sorry, and then 20 are in the various stages of development.

In the United States we have at least one very large-scale power example, Petra Nova Project near Houston. I took my board to see it. You know, you can see the CO2 pipe going in the ground. It is actually very instructive to actually say it is actually just a pipe and it's a bunch of—it is a bunch of chemical towers.

So, clearly, we can do it. There are dozens of injection projects around the country to prove that we can keep it under ground.

So the technology—I don't think there is any debate about that with currently technology we can do this and we can store it underground, and there has been lots of monitoring projects.

The real challenge is bringing the costs down and that is just a question of really scale up. It is the solar and wind story, basically.

Can you get—can you keep driving numbers and numbers and numbers to the point where, with the learning by doing, you get to a better price point?

The company that did the project in Houston has said that they believe that if they did a second unit they could bring the cost down 30 percent just based on what they learned from the first unit.

It is just a learning curve problem, in our view. So it is going be a lot of continued support probably from the Federal Government and from State Governments to just build that out and get to a point where we are in mass production.

Mr. PETERS. Ms. Angielski, I appreciate you mentioning the USE IT Act, which actually has been passed by the Senate and we could pass it—if we could pass it here in the House it would be great.

Can you talk about the role of that in terms of advancing this technology and how you think that might be helpful?

Ms. ANGIELSKI. So there is really two main components of that bill that I think are really interesting. One is that you are authorizing research at—for direct air capture as well as for carbon, if you capture carbon and you convert it into some other useful products.

And so that, to me, would really help to accelerate those technologies, and as I said in my testimony, transform the way that we are currently using carbon and create it into marketable products, which is something that would really contribute to the deep, deep carbonization objectives that we are talking about.

The other aspect of that bill would be to streamline permitting for projects and that would both for carbon capture project infrastructure, also as well for the pipelines that are needed to move around the CO2.

Mr. PETERS. Just for those people who are, maybe, not familiar with the technology, can you explain what the role of pipelines is in this sector? These are carbon dioxide pipes?

Ms. ANGIELSKI. Sure. So once you—you need infrastructure to capture carbon dioxide from the industrial flue gas stream and once you capture it you have to do something with it.

Mr. PETERS. Right.

Ms. ANGIELSKI. And so the most common way of moving CO2 is you pressurize it and you put it into a super critical state. So it is almost like a liquid fuel, and that typically is moved through pipelines.

And as I mentioned in my testimony, we have about 4,500 miles of carbon dioxide pipelines currently operating in this country. So we have existing infrastructure that we can tap into and——

Mr. PETERS. But it needs to be expanded, right? I am going to run out of time.

Ms. ANGIELSKI. It does. Exactly.

Mr. PETERS. I will just say I look forward to someday even talking about what else we might do with that carbon. But for the time being, I yield back.

Ms. CLARKE. The Chair now recognizes the gentleman from Texas, Mr. Flores, for five minutes.

Mr. FLORES. Thank you, Madam Chair, and I appreciate the panel for joining us today.

One of the things we don't celebrate is where the United States actually is—where we come from and the point we have achieved today, and we have done it through innovation and through focus on conservation, resiliency, and preparation.

And one of the things where I think we have been deficient is trying to figure out how to export that to the rest of the world and I think we need to do that.

I will give you a personal example of where I am. I commissioned a solar system on my home in late 2009. That immediately reduced my net electricity usage by 40 percent, and from—since then, from 2013 to 2018, I just did a quick—I was looking at my power monitoring system—did a quick and dirty spreadsheet and I produced my net electricity usage by another 42 percent and that is by switching to LED, tweaking the way our home automation system works, also tweaking the way we use our air conditioning and so forth.

So, I mean, this is very achievable to do this. But and I—we did that without any sort of government mandates or taxes. What we did it through was through conservation and innovation.

And I think we need to think about that as we pursue this and I also agree we need to look at it on a technologically neutral basis.

One of the things I didn't hear—I heard some about nuclear but I didn't really get the impression that there is as much enthusiasm about nuclear as I think we all need to look at.

We are not going to produce baseload power, and I think it was, Mr. Cohen, you had the chart to show California's examples. We are not going to produce enough power on a cost-effective basis by using 100 percent renewables.

If we really want to have baseload power we need to look at nuclear. Another thing we need to look at is the land use impact of renewables.

For instance, for every acre it takes to produce nuclear power it takes 3.5 acres to produce an equivalent amount of solar and it takes 5.7 to produce—acres to produce the same amount of wind and 25.3 acres to produce the same amount of hydro, and the only one of those that is conceivably close to being baseload is hydro.

So we need to look, I think, more broadly, at nuclear. That is the reason we have the Advanced Nuclear Fuels Act to fuel the next generation of reactors that passed the House in the last Congress.

It has also passed this committee and, hopefully, it'll pass the entire Congress to be signed by the president in this Congress.

Mr. Walberg and Mr. Crenshaw and I introduced the LEADING Act. It incentivizes R&D and carbon capture technologies, and that allows us to fully harness the environmental benefits of America's vast natural gas resources.

I do have some—you know, when we talk about the macro situation, look at the NASA Earth observatory Web site and it appears that total CO2 emissions from nature and man are—humankind are 219 gigatons a year and the total sequestration is about 250 gigatons a year, which means we are emitting about 4 gigatons a year into the atmosphere net that is not being sequestered.

So when we talk about sequestration of that amount, I would like to get an idea from you all as the cost of sequestration today and where you think it'll be in 2050, if you are qualified to—if you feel comfortable talking about that.

I would like to get the—get that answer in terms of trees and nature, direct atmospheric or air removal, and then CCUS from fossil fuels. Do you all have a feel for that cost today—cost per ton for CO2 removal?

Mr. COHEN. I think we can—well, I think Shannon can perhaps speak to the—for direct capture from flue gas. I guess, Shannon, I think—my guess is something in the range of $50 to $100 would be a fair—per ton would be a fair number.

Ms. ANGIELSKI. At least the testimony that I provided—my written testimony refers to recent IEA analysis that looks at some of those costs and it's the break even cost for capture and storage application, and they range from—anywhere from $5 U.S. per ton of CO2 that is stored upwards of $60.

I would say that I think some people think that these numbers are somewhat low from practical application. But there is at least a range that you can look at and that is for carbon capture.

And the gigaton scale that I mentioned in my testimony, that will be needed or at least projected by IEA that is needed to be captured and stored is—just for—from industrial uses is 100 gigatons.

That doesn't take into account other technologies that will contribute to that gigatons reduction that is needed.

Mr. FLORES. Yes. OK.

Mr. Hausker, you talked about direct removal from the atmosphere or the air. What is the cost for that today and where—I know this is pie in the sky stuff but we know that we will—technology will bend the cost curve down. Where do you think that could be in 2050?

Mr. HAUSKER. Some of the most recent engineering studies of what we could do with direct air captures is in the range of $200 per ton. I believe Professor David Keith recently issued a study.

So yes, as we go to scale and learn on almost any technology, costs tend to come down. So it is very promising.

Ms. CLARKE. The gentleman's time has expired.

Mr. FLORES. Thank you.

Ms. CLARKE. The Chair now recognizes Ms. Barragán of California for five minutes to ask questions.

Ms. BARRAGÁN. Thank you. Thank you, Madam Chairwoman.

I want to start the witnesses by being here today and for holding this hearing, which I think is so critically important. I was glad to see the committee yesterday make its announcement of moving forward on this—on this issue.

You know, I happen to represent a district that is very working class, a district that is majority minority. It is the type of district that has been on the front lines of disproportionately being impacted by climate change and air pollution.

And so to be able to see us address this in a way that is just and fair I think is so critically important. I want to start—my colleague started by saying he was concerned about the cost of what we were going to move forward with and harmful impacts of regulation, and I often tell people about the cost on people's lives.

How do you put a price tag—how do you put a cost on the public health impacts that are being—that our families and that our communities are being negatively impacted on?

In my district, we see cancer rates go up. We see asthma rates go up. As a matter of fact, the doctors' offices they keep the boxes of asthma inhalers just waiting for children to come by to give them out.

And so, so critically important. My first question is, you know, my district is surrounded by three freeways and the Port of Los Angeles.

Look at—Mr. Cohen, you provided some visual aids, and thank you for that. I am a visual learner.

The emissions coming from the transportation sector—we had a hearing here not long ago about the administration's rolling back of the clean fuel standards.

Maybe we can start with you, Mr. Cohen. Do you think that rolling these back is going to help us move in a positive direction to try to get to decarbonizing the economy?

Mr. COHEN. Certainly not. It is moving us backwards. I would even argue that we need to move a great deal more forward and I suggested something like a low-carbon fuel standard that would address the fuel as well as the efficiency.

But you mentioned the Port of Los Angeles and that is a good example of what can be done. The Port of Los Angeles has taken enormous efforts to electrify both the ships in berth as well as the landside vehicles to reduce emissions and they are also piloting hydrogen-powered freight at the Port.

So those are two examples of where you could very concretely start to drive down local emissions from transportation.

Ms. BARRAGÁN. Great. Thank you.

Dr. Cleetus, maybe you can weigh in on the rollback of the administration's clean fuel standards.

Dr. CLEETUS. This administration's posture on climate change is egregious, from denying the science to rolling back all—pretty much all the important policies we had on the books to address climate change.

It has been really deeply dismaying and does such a disservice to people around the country today and to our children and grandchildren.

The fuel economy and emission standards are key. No other current federal policy is delivering greater global warming emission reductions than these standards. So it is a huge problem that the administration wants to roll those back.

We need to keep them on the books. We need to set strong standards, going forward, to make sure that over time our vehicles are getting cleaner and cleaner, and this will also benefit consumers because it will save them money at the gas pump.

Ms. BARRAGÁN. Thank you.

There was a lot of conversation about a carbon price—a carbon fee. Environmental justice groups have had a lot of concerns. I have some concerns about the impacts of that on low-income communities and it being a regressive tax.

I am running low on time so I am not going to have an opportunity to ask more about that. But I do hope to follow up with you all about this because I often think that communities of color, low-income communities are not at the table to express their concerns on this and so would certainly like to hear more about what we can do. Are there ways to avoid that to get to where we need to get to.

But what I want to spend my last few seconds here on is my district also has a lot of industrial areas. The Alameda Corridor is there. As I mentioned, the Port is there.

I know one of you mentioned industrial areas at least in your testimony. What suggestions do you have for industrial areas like my district to get to decarbonize?

Mr. COHEN. There are two major—I don't know exactly what the composition of your industries are but for cement, steel, petrochemicals there are two major things you can do—two huge levers.

One is the—substituting another fuel input for the heat you need for these processes and, again, that can be zero-carbon hydrogen or ammonia or other zero-carbon fuels. And then on the back end we need carbon capture, which will actually capture the other pollutants as well, not just carbon.

Ms. BARRAGÁN. Thank you. I yield back.

Ms. CLARKE. The gentle lady yields back.

The Chair now recognizes Mr. Carter of Georgia for five minutes to ask questions.

Mr. CARTER. Thank you very much, Madam Chair, and thank all of you for being here. Certainly, an important subject, one that we all need to pay close attention to.

I want start with you, Ms. Angielski. I am sorry if I butchered that. But nevertheless, carbon capture technology—we talked about that today and it is certainly something that is talked about quite often, and it certainly has a promising role in what we are trying to do to reduce emissions.

I wanted to ask you, assuming that coal plants continue to come offline, and I suspect they will, and we will see more gas plants built not only because of the abundance but also because it is less emissions, if you will.

Can the technology for carbon capture—can that be retrofitted onto existing plants?

Ms. ANGIELSKI. It can. In fact, carbon capture technologies and what you are referring to is really primarily going to be called a post-combustion capture technology.

Many of those technologies, as I mentioned earlier, are really agnostic to the source of the CO2. It is just the concentration of the CO2 in that flue gas that needs to be accommodated in that capture equipment.

So you are just going to modify slightly the sorbent or solvent that is inside the equipment in order to capture it on gas plants, for example, or coal plants. So there is a leverage in investment opportunity. As importantly, they can be used in other industries.

So as Armond mentioned, we are going to need it, carbon capture in other industrial applications. So——

Mr. CARTER. How much do you capture?

Ms. ANGIELSKI. It depends on the technology. Some of these technologies can capture almost up to 99 to almost all of the CO2 emissions that come out of a fuel gas stream.

It is really a question of what the cost is to capture that must of the CO2 from just a process perspective. But the capability is there to achieve sort of a net zero emission.

Mr. CARTER. OK. Good.

In my district—in the 1st District of Georgia on the coast of Georgia—we have got a large manufacturer, Mitsubishi Hitachi Power Systems—and they manufacture gas turbines.

I have been out there visit them. Very impressive what they do. It is an exceptional business and exceptional company, and they are the most efficient gas turbines in the world that they are building out there.

And as they continue their research and development and they get even better, they'll become more efficient, and when we are replacing older coal fire or gas fire boilers as well as older gas turbines with these new more efficient gas turbines, the ones that can cut CO2 emissions by nearly 70 percent, how much carbon capture technology can we fit into the gas plant model? Can we fit that in there?

Ms. ANGIELSKI. There are a variety of different approaches that can be pursued with natural gas generation. Some of them are process technologies where you would—the turbine would be part of the overall energy conversion platform.

So we had mentioned earlier NetPower—something called the alum cycle. That is one natural gas technology that would, in its own right, be very highly efficient and then it just—a byproduct of that process is carbon capture already at pressure. So it just needs to be put into a pipeline and stored.

There are other technologies like we just mentioned that are post-combustion technology. So even with a very highly efficient gas plant, like you said, you may have a 70 percent emissions reduction from what you might be replacing that with. But you are still going to be emitting some amount of CO2——

Mr. CARTER. OK. All right. Great.

Ms. ANGIELSKI [continuing]. And you can still capture CO2 from those plants.

Mr. CARTER. Mr. Cohen, I want to get to you very quickly before my time runs out because I wanted to ask you, you made—in your testimony you said the American grid is a third carbon free between wind, solar, nuclear, and hydro.

And in the state of Georgia just north of my district we are the only place in the country that is building two nuclear reactors at this time. So I feel like nuclear is a big part of what we—what our future holds in the way of clean energy.

And I just wanted to ask you, do you think we should be placing more of an emphasis on nuclear power, especially when you consider stability in its output?

Mr. COHEN. Yes, absolutely. I actually sit on the board of an organization called the Nuclear Innovation Alliance that has exactly that objective.

There is a lot of work to do in terms of cheaper, faster, and more efficient reactors. We won't go into the Georgia situation. There were some important lessons learned.

Mr. CARTER. Right. Yes.

Mr. COHEN. Yes, that—we absolutely—having that in our toolkit would be an enormous step forward.

Mr. CARTER. And you are right, there is a lot of work left to do. But I would submit that perhaps the biggest work left for us to do and the largest obstacle and barrier for us to get over is just public acceptance of it.

And how do we do that?

Mr. COHEN. Well, I think cost is going to be an issue, too. I think we need to prove that we can bring these things on time and at budget or anywhere close to budget.

But I do think public acceptance is important. I do think that is changing, by the way. You know, my generation probably was inclined against the technology.

I talk to younger people who think climate is way more important than whatever concern they might have around the nuclear technology. I think it is shifting very rapidly.

Mr. CARTER. I hope you are right.

Thank you, and I yield back.

Ms. CLARKE. The gentleman yields back.

The gentle lady from California is now recognized, Ms. Matsui, for five minutes to ask questions.

Ms. MATSUI. Thank you very much, Madam Chair, and I am really pleased that this committee is holding this hearing to explore the many areas in which we can make progress in reducing emissions and combating the climate crisis.

And I must say, this was brought up before. But I think we know that one primary contributor to greenhouse gas emissions that is a particular concern and importance to all of us, especially me, is the transportation sector.

It is all around us. We know it. It is the largest single source of greenhouse gas emissions. Transportation emissions from heavy duty vehicle, passenger cars, and shipping, aviation will continue to rise and plague our cities with poor air quality.

We have discussed it before. There are pragmatic and achievable solutions to significantly reduce emissions across the board, something I have consistently worked with.

For instance, my bills, the Diesel Emissions Reduction Act and the one that I am really concerned about now—the Clean and Efficient Cars Act—which really does ensure that we keep the standards in place as far as fuel economy and greenhouse gas emissions, and I really think that those are sort of the low-hanging fruit, and I think those are the kinds of things that we ought to keep focusing on.

There are other things too that I want to talk about, too, and buildings electrification. I think that we can—we need to make real progress in reducing emissions and electrification of buildings.

Net zero buildings—buildings that utilize a combination of strategies to consume only as much energy as can be produced on site through renewable resources—have tremendous potential in solving the climate crisis.

My local utility, the Sacramento Municipal Utility District, otherwise known as SMUD, is doing great works toward greening our buildings by incentivizing the switch from gas to electric to perform functions such as heating and drying.

We should be encouraging that type of transition across the country and throughout the private sector.

Mr. Cohen, are there adequate policies and programs in place at the Federal level to incentivize the electrification of buildings, particularly within the private sector?

Mr. COHEN. I don't consider myself an expert in that area. I am not aware of any broad policies. I know there is some R&D focused on improving the technology, for example, for ground source heat pumps and that sort of thing.

Ms. MATSUI. Is anyone else aware of it?

Dr. CLEETUS. At this point, most of building codes and building standards stand to be at the local and state level. We do not yet have strong uniform federal standards across the board and the opportunity here is not just to make buildings efficient and electrified, and the opportunity is also to make them climate resilient in the process, especially in the way—in the face of the extreme weather events that we have been facing.

Huge opportunities are built here in private sector as well as in public housing where communities of color and low-income communities are particularly at risk when extreme weather events affect these buildings.

Ms. MATSUI. So this is an opportunity for housing advocates to be involved in this too, you know, as far as climate solutions and——

Dr. CLEETUS. Absolutely. Climate change touches everything in our economy and our society and there is a real opportunity here to lean in on the building sector in terms of becoming more efficient and low carbon.

Ms. MATSUI. Right. I know we've been talk about carbon capture an awful lot, and I think that seems to be the buzzword now today.

I think the National Academies of Science has reported last year that United States should launch a substantial research initiative to advance carbon dioxide removal through a full suite of approaches such as reforestation and soil management as well as scalable approaches like direct air capture and carbon mineralization.

Now, we are seeing states across the country launch carbon capture programs. For instance, California Air Resources Board last fall adopted amendments to our low-carbon fuel standard program to include a new CSS protocol that enable a wider deployment of CSS technology.

Mr. Hausker, how critical will a new research and development program on carbon dioxide removal be to meeting our climate objectives? Is this something we should be considering down the road or is it time now for us to invest and develop these technologies?

Mr. HAUSKER. It is time now to invest again, depending on what stage a particular technology is at. There may be a role for R&D at the Federal Government or for support through a tax mechanism like 45Q.

But as I emphasize in my—in my testimony, we can't wait until 2030 or 2040 to fully commercialize this. We need to act aggressively now.

Ms. MATSUI. So as you look at the future emissions trajectories, how important are scalable carbon dioxide removal approaches like direct air capture be to meeting our climate objectives? Is this an approach that is gradual and we are starting it now?

Mr. HAUSKER. We don't need to begin direct air capture now. We simply need to put in motion the forces that will let us begin to deploy it in the 2040–2050 range.

It is highly likely to be needed to remove carbon dioxide from the air in the mid-century range.

Ms. MATSUI. OK. That is fine. Thank you very much.

I just really feel also that we have things that we can do today that we should keep doing and, you know, we can't just wait for that.

Mr. HAUSKER. Absolutely. Absolutely.

Ms. MATSUI. OK. Fine. Thank you, and I yield back.

Ms. CLARKE. The gentle lady from California yields back.

The Chair now recognizes the gentleman from South Carolina, Mr. Duncan, for five minutes to ask questions.

Mr. DUNCAN. Thank you, Madam Chair, and I would like to put our first slide up, please.

All right. So this is the picture, and if you will take a look at it, it is just to make a point. But it shows a diesel-powered van pulling a gasoline-powered generator plugged into an electric vehicle that has run out of juice.

And the reason I put this up there is just to remind everyone that electricity has to be produced somehow. If we want to have more electrical vehicles on the road to lessen the carbon footprint, that electricity has got to be produced somehow.

So it can be produced through a lot of different methods. Nuclear power that Mr. Cohen has talked about, and we are going to go back to that, by the way. Hydroelectric power, but there is a lot of Californians on this committee and good luck building a hydroelectric dam in California under their policies.

Good luck building another hydroelectric project in this country under the current EPA rules and regulations. I think it is going to be very difficult.

You have got coal-fired power plants. You have got natural gas-fired power plants. You have got wind, solar. You have got small-modular reactors that can come online.

There is a lot of different ways to produce electricity and I truly am an all-of-the-above guy. I love wind and solar. I think it is groovy technology. I love the prospect of hydroelectric cars, hydrogen-powered cars. All these things.

But I also know that our economy demands a 24/7/365 baseload power supply, and let us just accept the understanding that the wind doesn't always blow and the sun doesn't always shine and that those renewables are intermittent.

And so because of the intermittency they have to be supplemented by something that will provide the 24/7 baseload power supply that Americans demand. Not just American manufacturing but Americans.

They like their refrigerator to have cold drinks in it. They like to have warm homes, cool homes, et cetera.

But we see, you know, the trend sort of shifting. There is a city in California now that is banning natural gas. And so they are not going to allow in new homes or new businesses to have natural gas to power their HVAC units or possibly to power their stoves to cook on.

So Berkeley is actually moving their constituents toward more expensive and less efficient energy sources for their homes. HVACs that are powered by electricity are less efficient. Electricity is more expensive than natural gas and the stoves are less efficient and electricity is more expensive.

So thinking about electrical generation, let us shift gears and put the second slide up. I want to talk about nuclear energy and the important role it plays in the all-of-the-above energy matrix.

Now, my home state of South Carolina has seven nuclear power reactors. They produce 95 percent of the state's emission-free electricity, 53 percent of our total electricity.

In my district, Oconee Nuclear Station has three nuclear reactors. Let's just talk about one of those. Three nuclear reactors provide 2,550 megawatts of carbon-free continuous always-on power for South Carolina and North Carolina.

If we replace the Oconee Nuclear Station, which uses less than two square miles, with solar it would require 107 square miles of land, nearly four times the size of our largest city in upstate Greenville.

If we replace Oconee Nuclear Station with wind power, that will require over 854 square miles of land. That is more land than the entire county of Anderson, my largest county in my district.

So this slide shows how you would replace one nuclear reactor that is 1,154 megawatts with wind. It would take 2,077 windmills and there are 2,077 windmills on this graph. Two thousand seventy-seven windmills, 2 megawatt wind generators, to replace one solar reactor.

Think about the land mass that that would take to provide the wind power for that one reactor. Nuclear power is emission-free.

Mr. Cohen, how can we further more nuclear power to lessen our carbon emission as part of this energy matrix?

Mr. COHEN. Yes, that is probably a subject for another hearing. I would just say there are three things. One is let us get on with the RD&D demonstration of the next generation of reactors that will be less expensive and faster to build.

Secondly, we need to address the U.S. waste problem and—well, those two would be a good running start.

Mr. DUNCAN. You mentioned earlier some of the things that are hampering nuclear power. In South Carolina, we were building two more nuclear reactors and the company had to stop because regulations by the government during the construction process—not during the permit approval process, during the construction process—changed so much that the cost went up, and that had to be mothballed. So now we are not having that nuclear power generation to meet our future electrical needs.

How do we overcome the regulatory environment within a cost-benefit application that will support the growth of the nuclear industry?

Mr. COHEN. We have been supporting, you know, much more performance-based regulation. I do think the situation in South Carolina is a little more complicated than that. It is probably the subject of another hearing. There is a lot of blame to go around on that. I think——

Mr. DUNCAN. In the five-minute we have to—you know, you can't be that complicated in five minutes.

Ms. CLARKE. The gentleman's time——

Mr. COHEN. I don't think the NRC—I don't think the NRC bears all the blame in that situation.

Ms. CLARKE. The gentleman's time has expired.

Mr. DUNCAN. Thank you.

Ms. CLARKE. The Chair now recognizes the gentleman from Florida, Mr. Soto, for five minutes to ask questions.

Mr. SOTO. Thank you, Madam Chairwoman.

We are here today—like with our press conference yesterday we are here to act on climate and get to 100 percent clean energy by 2050, and that is going to take reducing carbon emissions to net zero.

So we know the goals. We have been told by various scientific groups like the Center for Climate and Energy Solutions there are four main elements to decarbonization.

One, transition to low-carbon electricity system; two, reduce emissions from transportation, buildings, industrial sectors; three, to deploy negative emissions measures; and four, to reduce non-COT greenhouse gas emissions.

So I just want to ask all the panellists first do you all agree with these basic elements? Is this the recipe to get us to 100 percent clean energy by 2050?

And we will start from left to right.

Mr. HAUSKER. CCES is a great group and that's a great report you cited. Their four strategies sort of overlap with the four strategies I mention in my testimony. But it is not inconsistent.

Everything I said was focused on the energy sector and CO2 but they highlight the need to reduce the non-CO2 emissions, which are also sometimes called super pollutants, and Armond has discussed those today.

Mr. SOTO. So do you believe that's a basic recipe? We may argue over which is more prioritized.

Mr. HAUSKER. It is a good recipe. It is an equally good framing as the one that I set out.

Ms. ANGIELSKI. I can comment that yes, we can transition to a low-carbon electric grid.

Mr. SOTO. Would you say that this is a comprehensive list of the four elements that we need to work on regardless of what priority everybody may have of these elements?

Ms. ANGIELSKI. Yes, in looking at the sources of CO2, absolutely.

Mr. SOTO. Mr. Cohen?

Mr. COHEN. That's a complete solution, sir.

Mr. SOTO. Dr. Cleetus, is this the four—is this the recipe right here?

Dr. CLEETUS. So that is the technological solutions—that we have to address this as a deep socioeconomic change as well. So we need just transition investments in communities that are going to be affected as we transition away from fossil fuels.

We need policies that will center equity and how we deal with climate change and we have a political challenge here in the United States as well as globally.

So these are—this is not just a technological problem. But yes, those are the core elements of decarbonizing the economy, which needs a whole suite of other changes alongside.

Mr. SOTO. Thank you, Dr. Cleetus. And we will worry about the political challenges right here on this committee. But I appreciate you bringing them up.

I wanted to follow up on some line of questioning that Representative Peters has already discussed with regard to negative emissions, trying to reduce carbon in the atmosphere already. Could each of you give me one strategy that you would recommend since that seems to be one of the—one of the areas that we aren't as aggressive on yet?

Mr. HAUSKER. I will just mention one and I am sure my colleagues will mention the others is through improved forestry, planting of trees, and agricultural changes, we can store—we can enhance the sequestration of CO2 in forests. And so——

Mr. SOTO. So forestry and—sorry, my time is limited—forestry and more trees. I totally agree. Next.

Ms. ANGIELSKI. I would say direct air capture is another pathway.

Mr. SOTO. Direct air capture. I think that covers it.

OK. Dr. Cleetus?

Dr. CLEETUS. Yes. The natural solutions are ones that we should prioritize, recognizing that climate change itself is affecting our natural sync.

We have seen a record heat wave in Alaska this year, for example, every time we have wildfires. If permafrost starts to melt, that natural sync is getting eroded. So we need to keep that in mind.

Mr. SOTO. Thank you. I also wanted to correct a misstatement that was made so far on the committee. There were turbine graphics that were put up that were based upon two megawatt wind turbines, and we now have 12 megawatt wind turbines offshore. So I think it is important to correct the record on that.

I want to end by talking about some of the themes that we talked about yesterday in committee. First, we have to trust the science as best we can and help it lead us to the solutions. I think that is actually easier than the second part, which is building consensus.

But it is absolutely critical that we build consensus. We are getting tugged from every which way politically around here, and we are not going to please every single person in the Congress.

But we need a working majority of Democrats and Republicans who are going to come together to get a bill that will—a slate of bills that will get us to this 100 percent clean energy in 2050, and the only thing we can't afford to do is inaction.

We have to act on climate. And so thank you, Chairwoman, for the opportunity and I yield back.

Mr. TONKO [presiding]. The gentleman yields back.

And the Chair now recognizes the gentleman from West Virginia, Mr. McKinley, for five minutes.

Mr. MCKINLEY. Thank you, Mr. Chairman.

And I agree with the panel and all of the people here about the United States must do its part to decrease greenhouse gas emissions.

But we have got to keep in mind this is a global issue and not one confined to the United States. An MIT report that I have a copy of here—MIT report came out that says it matters little to the global environment what the United States does to decarbonize its economy.

If emissions in China and India continue to go unabated, coastal cities in the United States will still flood. Wildfires, droughts, and storms will continue.

So it is not going to fall entirely on the United States. I also appreciate the potential for renewables. But they are currently limited. Even Secretary Moniz expressed his doubts in remarks he made earlier this year.

He said as recently as February—he said 100 percent renewables by 2015 is not realistic and certainly not cost effective. Then followed with that, a study by Wood Mackenzie calculated that for us to go to 100 percent renewables and have the cleanest energy possible we would require 900 gigawatts of battery storage. Nine hundred gigawatts of battery storage.

Now, what do we have now? Totally around the globe we only have 5½ gigawatts battery storage. But we need just in America alone 900.

So meanwhile, the rest of the world still has this voracious appetite for coal because it's cheap and easy to make. IEA says that they are still going to mount—by 2040 they are still—75 percent of the power is going to come from fossil fuels.

So I think I go back to remarks that were made earlier. America has the capacity and the wherewithal to innovate, to lead in innovation, and that means putting significantly more money into carbon capture—significantly more money.

And I would include too on that, Dr. Hausker, I think they need to look at how we are going to spend biologically in phytoplankton as part of that. So I want to come back to you on that.

So in so doing, if we can capture—if we can lead again on this, we can then export this technology to the other nations and help them out.

So if I could go to Ms. Angielski, I have given you some quotes from Secretary Moniz. Was he right?

Ms. ANGIELSKI. With respect to renewables—is that what you're referring to?

Mr. MCKINLEY. Yes.

Ms. ANGIELSKI. You know, I don't want to comment on the capability of renewables technology but I will say that I do—I think there are issues that haven't been discussed with respect to going to 100 percent renewables, and you touched on them, which is the capability of storage technologies and the environmental sustainability as well.

Mr. MCKINLEY. Do you agree with MIT's assessment?

Ms. ANGIELSKI. Yes.

Mr. MCKINLEY. That the—that the reliance of India and China is putting the globe at risk? It is not the United States because we are already decreasing our CO2 emissions.

Ms. ANGIELSKI. Correct.

Mr. MCKINLEY. Would you agree?

Ms. ANGIELSKI. So I would agree.

Mr. McKINLEY. And do you—what about Wood Mackenzie's report about the—so you have a concern too then about the amount of battery storage and batter capabilities?

Ms. ANGIELSKI. Battery storage. Right.

Well, one thing that we don't talk about is where we get the materials for those batteries and how we have to mine them and develop them, and the greenhouse gas profile or the environmental sustainability of those.

So, potentially, the subject of another hearing but certainly that in and of itself could present a geopolitical challenge as well.

Mr. McKINLEY. There was a question—I think it was Mr. Carter, perhaps, asked it or someone down on my left—asked about whether we could retrofit. And so the question I was hoping someone would speak up on this—so let me—I will ask the question a slightly different way.

How would the New Source Review reform—New Source Review reform—how would it impact retrofitting for carbon capture technology? What do we—do we need some New Source Review reform?

Ms. ANGIELSKI. So I will refer really to the Petra Nova project, which really had to face that potential challenge when they were retrofitting their existing coal plants with this carbon capture system.

They decided in order to not open up their existing permit which would then trigger New Source Review they decided to build a separate power plant to power that facility.

That model is not likely something that can be replicated by every coal-fire power plant or natural gas-fired power plant in this country. So potentially that could be a deterrent for retrofitting with carbon capture.

Mr. McKINLEY. I have got one quick question back to Dr. Hausker.

Are we spending enough money biologically to try to do some engineering work in phytoplankton?

Mr. HAUSKER. Are you referring to algae-based biofuels, sir?

Mr. McKINLEY. No, just in the oceans. The phytoplankton—you understand its role, right?

Mr. HAUSKER. I am sorry. I am not sure if you are talking about the production of biofuels or if you are talking about——

Mr. McKINLEY. No, I am talking about phytoplankton in the oceans.

Mr. HAUSKER. As a—as a sequestration option?

Mr. McKINLEY. It is the—sorry. Fifty percent of the oxygen through the sink process—the photosynthesis process comes through phytoplankton as much as trees, shrubs, grass, and everything else.

So I was a little surprised—we need to be focusing more on what we are going to do in the oceans to be able to increase the phytoplankton content so that we can increase their CO2 capture.

I yield back.

Mr. HAUSKER. Yes. I am not an expert on that so I don't know the potential for increase in ocean sequestration as you describe. But I would be happy to get back to you if I can find some expert——

Mr. McKINLEY. Please, if you could. Thank you.

Mr. TONKO. The gentleman yields back.

The Chair now recognizes the gentle lady from Colorado, Ms. DeGette, for five minutes.

Ms. DEGETTE. Thank you so much, Mr. Chairman.

This is a really important hearing and I have been watching the testimony and the questioning of the witnesses.

We have all talked about the fact that climate science indicates we need to cut net global greenhouse gas emissions in half in 10 years and then reduce the net emissions to zero in 30 years or we will expose our children, grandchildren, and their children to great risk.

I think all of us agree that the science is important and we need to do this. But it's not going to be easy.

So I want to ask some questions to you about the science. First of all, for everybody, do you agree that many of the technologies that we are going to need for these emission cuts are either commercially available or approaching commercial availability?

Mr. Hausker?

Mr. HAUSKER. Yes, I think there is a wide range of technologies. Yes.

Ms. DEGETTE. OK. How about you, Dr. Cleetus?

Dr. CLEETUS. Absolutely yes.

Ms. DEGETTE. OK. And how about you, Mr. Cohen?

Mr. COHEN. Yes.

Ms. DEGETTE. And how about you, Ms. Angielski?

Ms. ANGIELSKI. Yes.

Ms. DEGETTE. OK. So all of you agree that we have those technologies available and they are becoming more cost effective, I think.

I wanted to ask you something that is kind of looming out there for people like me who are trying to work in a bipartisan way on climate legislation and that's this. We have all been talking about this goal of zero by 2050. Could we do zero technologically and economically within 10 years?

And I will start with you, Mr. Hausker.

Mr. HAUSKER. I think it would be extremely difficult and expensive to go to net zero in 10 years.

Ms. DEGETTE. And would it have severe societal ramifications?

Mr. HAUSKER. I think it would—it would be very costly and I think there would be push back.

Ms. DEGETTE. What about you, Ms. Angielski? What is your view?

Ms. ANGIELSKI. What I would say is that the capability exists to get to net zero, which I think was your first question.

Ms. DEGETTE. In 10 years?

Ms. ANGIELSKI. But the time frame is questionable, as I think Dr. Hausker said. I mean, what we really need to do is innovate more to help improve the technology and reduce costs, instead of putting a time frame of 10 years on it might not be practical.

Ms. DEGETTE. OK. And what is your view, Mr. Cohen?

Mr. COHEN. Technically possible, economically challenging.

Ms. DEGETTE. And are you aware of any studies that would show the cost?

Mr. COHEN. Of the accelerations of moving the——

Ms. DEGETTE. Right.

Mr. COHEN. I am not but I can look into that.

Ms. DEGETTE. If you can I would appreciate that.

Dr. Cleetus, what is your view on this?

Dr. CLEETUS. Ten years will be deeply challenging. But what we have to get moving right away and get as far as we can in that 10 years because the science is really sobering.

Ms. DEGETTE. I totally agree with you and, in fact, you know, in my state of Colorado, some of you probably know we did this renewable energy standard and the power companies totally opposed it and so we had to do it by ballot initiative and then we were able to achieve the goals in just a few years.

And so we actually went back in and increased it legislatively with the support of all of the energy companies. So it is the kind of thing if we get started now we may be able to increase it.

But what we are trying to think about is what kind of reasonable legislation can we pass to make that happen and I am wondering when you all say it would be technologically feasible but very expensive what kinds of things would we have to do to reach that in 10 years?

Dr. Hausker?

Mr. HAUSKER. I think I can throw some light on that. A lot of it is related to capital stock turnover and different things—different important pieces of energy-using equipment have different lifetimes. A car may have a lifetime of 15 years.

A water heater may have a life of 10 years. A building may have a life of a hundred years. An industrial plant. So the way to decarbonize effectively but not incur really huge costs is to try to use our existing capital stock and when it turns over that's when you go with the very efficient zero-carbon——

Ms. DEGETTE. I got you. I have no idea how much time I have left. So I have one more question, if I may, Madam Chair.

Is my time up?

Ms. CLARKE [presiding]. Your time has expired.

Ms. DEGETTE. OK. Well, the question I have, which I'd like a written answer, to everybody is a lot of people talk about natural gas as a bridge fuel to get to zero carbon.

The question I'd like you to give me an answer in writing is that's only a bridge fuel if we deal with the methane, as near as I can understand, because if you don't deal with the methane then you're not going to be able to get carbon capture.

With that, I will yield back. And I apologize. I don't know what's going on with the——

Ms. CLARKE. The gentle lady yields back.

The Chair now recognizes the gentleman from California, Mr. McNerney, for five minutes to ask questions.

Mr. MCNERNEY. I thank the Chair and I thank the panelists for testifying this morning.

The warming of the planet is accelerating and I am convinced that we are going to blow past the two degrees Celsius increase, exceeding the limits that the IPCC is calling for no matter what we do in terms of carbon emission reductions.

Consequently, we need to be looking at all the potential tools in our climate solution toolbox including funding research for climate intervention and geoengineering. Given the complexity of the climate system and the risks that are associated with interfering in it, how do you think the U.S. Government should field a research on climate intervention, starting with Dr. Hausker and going down?

Mr. HAUSKER. It merits some—it merits some research. It is a very controversial area, however.

Ms. ANGIELSKI. This is not something that I have studied so I can't comment on this. I'll defer to my colleagues.

Mr. COHEN. Research in two areas is required. One is the physical systems and also we need to think really about governance—what would you do if you actually had these technologies to deploy.

Mr. MCNERNEY. Thank you.

Dr. CLEETUS. Cutting emissions and investing in climate resilience have to be our first line solutions here. But given where we are from a climate perspective, it is appropriate for us to have a better understanding of the risks and potential of things like geoengineering.

However, we oppose any deployment of the technology at this point. There are too many risks associated with it, too many unknowns.

We think there is a role for small-scale experiments but only if accompanied by very strong governance regimes to make sure that all of the risks are being appropriately accounted for.

At this point, the U.S. government has stepped so far away from its responsibilities in terms of resilience and cutting emissions that we do not think that under the current administration it would be a responsible move to deflect attention towards this type of a technology development right now.

Mr. MCNERNEY. Thank you, and I agree. We don't know enough about the science to decide one way or the other right now if geoengineering is appropriate and we need to invest to make the science available so that we will understand what the consequences and risks are.

Mr. Cohen, direct emissions, which are from industry, make the industrial sector the third largest source of greenhouse gas emissions. It is also one of the hardest to decarbonize.

Currently, the greatest impediments to commercializing, deploying, and eventually what are the biggest impediments to moving to decarbonizing the industrial sector?

Mr. COHEN. Well, it is—let me start with the solutions. I mean, really, there are two main problems or two main sources of CO2 from industry. There is the process heat on the front end and that is provided by fossil fuels today—unabated fossil fuels—and then there is inherent CO2 coming out the back end for things like steel and cement production.

So, as I said earlier, the two major solution pathways would be to substitute a high-temperature source of heat for the fossil fuels and that could be from nuclear—from high-temperature nuclear. It could be from a hydrogen manufactured from a number of sources, and then on the back end, carbon capture.

The impediment right now to implementing those are actually not technical. We have got demonstrations of both of those technologies in place on large industrial facilities around the world.

It's going to be driving the costs down and making them really a feasible—economically feasible solution for those big heavy industries.

Mr. MCNERNEY. Well, I spent a career developing wind energy technology and I see renewables being significant in the sense that you can overproduce energy and renewables and then you have periods where there is no production, and the overproduction you could create hydrogen by breaking water.

There is things that we can do. I think the efficiency—the round trip efficiency of breaking water and then burning hydrogen is not what we need it to be. But there is——

Mr. COHEN. That is one pathway. The only caution I would put on that is that you have maybe some of the same issues with intermittence on the grid that you would have with electrolysis. That is, you build an electrolysis plant if you're running it at very low capacity because you are relying only on variable sources of energy might have some issues. But in principle, yes, renewable energy can be a hydrogen source.

Mr. MCNERNEY. Ms. Angielski, is there a economic method to create carbon fiber from carbon dioxide?

Ms. ANGIELSKI. I am not intimately familiar with carbon fiber production but, certainly, there are research programs underway at DOE at looking at novel markets like carbon fibers, for example, and converting that CO2 into marketable products. So I am aware of companies are investing in the development of that but at the scale that would be needed to really store CO2 in those fibers I am not on exactly where they are with that right now.

Mr. MCNERNEY. Thank you. I yield back.

Ms. CLARKE. The gentleman yields back.

The Chair now recognizes the gentle lady from Michigan, Mrs. Dingell, for five minutes to ask questions.

Mrs. DINGELL. Thank you, Madam Chairwoman, and I want to thank Chairman Tonko for holding this hearing. I want to thank all the witnesses for being here because I do think we really are at a critical moment in our human history.

The planet is warming. The ice is melting. The seas are rising. We are seeing the heat waves. I really felt it with 111 degrees and no air conditioning this weekend.

The droughts, floods, and wildfires are ravaging our communities and nobody can deny we are seeing the hurricanes. And the one thing we do have agreement on all of our best and brightest scientists agree the climate is changing with every amount of carbon that is being emitted across the economy.

So I just want to say we have got to find the will and we have got to do it together. So it means all the stakeholders, all the industry, and there are a lot of complicated issues.

I am a car girl and I will always be proud of being a car girl, and transportation industry is a part of this not only in the United States but in it worldwide, and I am not—don't have enough time even to ask questions about what is happening here versus other countries who are really taking that on.

But I think every great human achievement begins with a goal and the goal for the moment, I think, is 100 by '50, meaning we set a course to achieve—it's a goal to set 100 percent clean energy economy by 2050.

I am working on a bill with my colleague, Mr. McEachin, and others that will establish 100 percent clean energy economy goal by 2050 and we hope to introduce the legislation soon.

But I want to ask some questions because everybody says it's ambitious, and then I do have young people that are in my district office and everyplace I am going telling me we are not being ambitious enough soon enough.

And it is—you know, we need to have the vision, a goal, and how do we get there as fast as we can.

First, a quick question to all of you. A quick yes or no from the panel. Do you believe with American ingenuity and spirit we can find the collective will to get there?

Dr. Hausker?

Mr. HAUSKER. Absolutely, yes.

Ms. ANGIELSKI. Yes.

Mr. COHEN. Yes.

Dr. CLEETUS. We can and we must.

Mrs. DINGELL. That is great. OK.

Dr. Cleetus, I am going to ask you some questions. Can you reiterate why it's so critical, as you just had in your passion again set a 100 by '50 goal today and why it is so urgent?

Dr. CLEETUS. It's urgent because of the climate impacts we are already feeling at one degree Celsius right now. As you pointed out, the terrible heat waves that we are seeing, the wildfires, the flooding, the intensified storms—this points out to us that we are already paying the costs of climate change.

We have heard several Congress people today point out that making a clean energy transition will come with some investment costs. But those costs pale in comparison to runaway climate change.

We need to address this problem because we owe it to our children and grandchildren. Those young people who are urging us to be ambitious, this is about the world we are leaving them.

Mrs. DINGELL. Thank you.

Mr. Cohen, I am going to ask you these questions. I am going to—because I do come from Michigan, I am going to do electric vehicles. With the rollout of more and more electric vehicles, how would electrifying the transportation sector help us achieve a net zero carbon pollution by 2050?

Mr. COHEN. Well, clearly, if we are decarbonizing the grid at the same time we are doing that we are going to be reducing net carbon. That is, obviously, a great step forward.

Mrs. DINGELL. How do we accelerate the rollout of electric vehicles and the need for the infrastructure? I have heard all of you—not all of you but some—express concern about the battery capability.

There is no consumer confidence in the electric vehicles and we are not building the grid we need to do to build it. It's a chicken and egg. What do we need to do?

Mr. COHEN. So, well, the first thing I think we need to do is think about increasing the penetration of both electric vehicle take-up and the charging infrastructure.

But as I said earlier, I think we also need some other pathways. And so I think these zero-carbon fuels could provide, particularly for heavy freight, could provide a backstop or a complement.

I think we have to be going both ways at once. A zero—a technology-neutral low-carbon fuel standard analogous to what people have proposed on the electricity side would probably provide a really good market signal.

Mrs. DINGELL. I am going to—because I am almost out of time I am going to ask Dr. Cleetus this question because fuel economy standards came up earlier.

And how do they fit into the range of tools we have discussed today to decarbonize our economy? Would they help us get to 100 by '50? And I do think they need to—personally, believe we need year to year increases.

How do we do it in a real—part of the challenge for all of us is how we do all of this in the fastest way but the real way.

Dr. CLEETUS. So the interesting thing about it is doing it together is actually the cost effective way to do it. We can clean up the economy better if we are simultaneously building out the infrastructure in the transportation sector to electrify as much as we can even as we decarbonize the grid. We need to do those together.

The fuel economy standards are critical. Right now, as we all said, the transportation sector is the biggest contributor to U.S. greenhouse gas emissions. Emissions are rising in this sector.

Those fuel economy standards are going to deliver a huge benefit in terms of emission reductions as well as consumer benefits, public health, and lowering their bills for fuel.

Mrs. DINGELL. Thank you, Madam Chair.

Ms. CLARKE. The gentle lady yields back.

The Chair now recognizes the gentleman from Virginia, Mr. McEachin, for five minutes to ask questions.

Mr. MCEACHIN. Thank you, Madam Chair.

I want to start off by thanking both Chairman Pallone and Chairman Tonko for their leadership in this area and for having this hearing.

I am honored to serve with them as we work to preserve and protect our planet. There is no issue more important than preventing and mitigating climate change and speeding our transition to a clean energy economy.

Their leadership is helping to ensure that we create a healthy sustainable planet for future generations and I am humbled to be their partner in that work.

The best science says we need to completely stop adding climate pollution to the atmosphere by 2050 if not sooner. That is why I am fighting for bold action now.

That is why I will be introducing legislation along with Congresswoman Haaland, Congresswoman Dingell, Congresswoman Blumenauer, and Chairman Tonko to transition the United States to 100 percent clean energy economy.

A hundred percent clean will protect public health and our environment, create well-paying clean jobs, and strengthen our economy. It will mitigate the impacts of climate change for all communities and all generations, especially those disproportionately impacted by its worst effects.

As we engage in this important policy work, we must break the decades-long cycle of environmental injustice. For much of our history, unjust policies have caused many of our most vulnerable friends and neighbors to lead sicker, shorter, and more difficult lives.

So we desperately need climate action and we desperately need climate justice, and we cannot have one without the other.

Dr. Cleetus—did I pronounce that correctly?

Dr. CLEETUS. Yes.

Mr. MCEACHIN. OK. Thank you.

A just cause and a fighting spirit do not guarantee success and we have only one chance for climate change. We have to hit our marks.

When it comes to reducing emissions, can you speak to what kind of processes as distinct from technologies or policy choices are most apt to move the needle?

End goals are crucially important but is there a value in interim goals and in regularly scheduled checkups and progress reports?

Dr. CLEETUS. Thank you, Congressman McEachin, and I just want to thank you and Congressman Grijalva for the way in which you have centered environmental justice in addressing this problem of climate change.

In terms of the processes, I would say two things. Absolutely we do need interim goals. This is not just about 2050. This is about where we get in the next decade as well, because in that time we have the opportunity to get very far in cutting emission reduction emissions and we have the opportunity also to make sure that we are protecting people from the climate impacts already underway.

We need to engage directly with stakeholders in communities that have often been left on the sidelines of this challenge. Environmental justice communities have solutions to this problem and they must have a seat at the table as we go about solving this problem.

Just last week, there was a national platform released by environmental justice groups and national environmental groups—an equitable and just national climate platform which has many elements in it of what that process could look like and the vision for an equitable-centered climate platform.

Mr. MCEACHIN. Thank you.

Doctor, once we make a formal commitment to act, how do we make real-time adjustments and keep ourselves on a path to success?

Dr. CLEETUS. The opportunity we have here is if we get going in an ambitious way the costs of technologies are falling all the time. Folks on the panel have pointed out wind, solar.

We have seen double-digit cost declines year over year. We have seen battery storage costs come down. Just in the last decade over a 70 percent reduction in wind and solar costs.

So if we get started in an ambitious way the opportunity we will have is that when we get five years out or 10 years out, we know we can ratchet up ambition because the costs of these technologies will have fallen.

Mr. MCEACHIN. Thank you.

You have said that, done right, an economy wide low-carbon energy transition can also help address longstanding inequities of low income communities and communities of color.

I need you to expound upon that. Is there a danger that we end up with climate action in the absence of climate justice or vice versa, and if so, how can we best avoid those dangers?

Dr. CLEETUS. Solving climate change in an equitable way won't happen by accident. We have to have that intentionality from the beginning to center equity.

We know that as we cut CO2 emissions we have the opportunity to cut other co-pollutants that are causing near-term public health burdens in these communities from mercury, from particulate matter, from sulfur dioxide emissions, NOX emissions.

So the opportunity we have is making sure that we are making emission cuts and prioritizing emission cuts in communities that are overburdened by these other kinds of co-pollutants even as we cut carbon dioxide pollutants.

The other opportunity we have is to make sure that the benefits of clean energy are accruing directly to these communities—that they have access to these modern clean technologies, the efficient technologies that can save people money as well as make sure that they too will clean up the air and water in their communities.

Mr. MCEACHIN. Thank you. I thank the witnesses and I thank you, Madam Chair. I yield back.

Ms. CLARKE. The gentleman yields back.

I request unanimous consent to enter the following documents into the record: a letter from the International Brotherhood of Electrical Workers and the Nuclear Energy Institute, three facts sheets from the Nuclear Energy Institute, and a report from the BlueGreen Alliance on its platform for climate action.

Hearing no objection, so ordered.

Ms. CLARKE. I would like to thank all of our witnesses for joining us here at today's hearing. I remind Members that pursuant to committee rules, they have 10 business days to submit additional questions for the record to be answered by our witnesses.

I ask each witness to respond promptly to any such questions that you may receive.

At this time, the subcommittee is adjourned.

[Whereupon, at 12:30 p.m., the committee was adjourned.]

[Material submitted for inclusion in the record follows:]

BLUEGREEN ALLIANCE

CREATING GOOD JOBS, A CLEAN ENVIRONMENT, AND A FAIR AND THRIVING ECONOMY

July 24, 2019

The Honorable Paul Tonko
Chairman
Subcommittee on Environment
and Climate Change
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable John Shimkus
Ranking Member
Subcommittee on Environment
and Climate Change
2322 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Tonko and Ranking Member Shimkus,

Thank you for holding the important hearing today entitled "Building America's Clean Future: Pathways to Decarbonize the Economy." BlueGreen Alliance recently released its platform "Solidarity for Climate Action," which offers a practicable and achievable vision to create and sustain quality jobs for workers in communities around the country, while fighting economic inequality and addressing the climate crisis. We hope you will consider this platform as you work to achieve the goals of combatting climate change and creating a fair economy.

Sincerely,

Mike Williams
Interim Co-Executive Director
BlueGreen Alliance

1300 Godward Street NE, Suite 2625
Minneapolis, MN 55413 | 1020 19th Street NW, Suite 600
Washington, D.C. 20036 | 369 Pine Street, Suite 700
San Francisco, CA 94104

BLUEGREEN
ALLIANCE

SOLIDARITY FOR CLIMATE ACTION

The BlueGreen Alliance and its labor and environmental partners are committed to the vision, principles, and policies outlined in this document, and are committed to a process of working together to identify concrete solutions to achieve these goals.

Vision

Americans face the dual crises of climate change and increasing economic inequality, and for far too long, we've allowed the forces driving both crises to create a wedge between the need for economic security and a living environment. We know this is a false choice—we know that we can and must have both, and we need a bold plan to address both simultaneously.

Many solutions are already being put into place across the country. For example, tradespeople built the Block Island offshore wind project off the coast of Rhode Island, autoworkers are on the factory floors building cleaner cars and trucks in Michigan, and previously unemployed workers in St. Louis and Los Angeles are gaining access to high-skilled jobs in energy efficiency retrofitting, pipefitting, and transit manufacturing, while mine workers are extracting palladium to be used in catalytic converters. These are all good, union jobs building a clean energy and climate-resilient economy today.

At the same time, not enough of the new jobs that have been created or promised in the clean energy economy are high-quality, family-sustaining jobs, nor are these jobs in the same communities that have seen the loss of good-paying, union jobs. Wildfires, hurricanes, heat waves, droughts, and sea-level rise driven by climate change are hurting communities across the country and will only worsen if we don't take decisive action. Lower income workers and communities of color are hit the hardest and are less able to deal with these impacts as wages have fallen and their economic mobility and power in the workplace has declined.

It is critical that working people are front and center as we create a new economy: one that values our work, our families, our communities, and our environment. It is with that imperative that we call for a new plan to create jobs and protect the environment for the next generation. This plan must respond to the climate crisis on the scale that science demands, while simultaneously addressing inequality in all its forms.

Principles

Climate Stability: It is projected that the emissions path the world is currently on could result in an increase in global average temperature above pre-industrial levels of at least 2.5°C—and could exceed 4°C by 2100—if some countries do not fulfill their Paris Agreement commitments. This will have devastating impacts on both human communities and natural ecosystems. According to the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Global Warming, we must act now to shield workers and communities from increased climate disasters: "Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society," which "could go hand in hand with ensuring a more sustainable and equitable society." This global effort to address climate change and inequality must happen at the speed and scale demanded by scientific reality and the urgent needs of our communities.

High-Quality Jobs: We must strive to create and retain millions of high-quality jobs while putting forward bold solutions to climate change. Unions are a primary vehicle to confront the economic insecurity most Americans face. Unions empower workers, create quality jobs, and sustain families. Making union jobs more accessible to all and increasing our nation's union density will lift up all working people. When working people have power, they have greater capacity to fight for change.

Community Resilience: We must dramatically increase the capacity of the public sector, the health care system, and community-based non-profit sectors to prepare for and respond to the demands our changing climate places on first responders, healthcare workers, social workers, and others who deal with climate-induced disasters. We must also deal with the increasing stresses placed on communities and the health of workers due to more gradual manifestations of climate change. We need to expand public and private sector investments in our infrastructure and built environment that incorporate social, environmental, and economic considerations. We must support the efforts of frontline communities to adapt to and recover from the increased frequency and severity of climate change-induced natural disasters and impacts, ensuring that resources flow to those most impacted.

Repair America: We cannot address climate change with derelict infrastructure. It is time we made the long and deep commitment to fully and properly remake and modernize all sectors of our nation's infrastructure, while also building out the new systems demanded by an advanced economy dealing with climate change demands. Infrastructure must be designed in ways that reduce emissions and that reflect projected conditions over its lifespan, including the ability to withstand the increased frequency and severity of climate-driven natural disasters.

Rebuild American Manufacturing: American leadership in inventing—and manufacturing—the most advanced technology of all kinds was once a cornerstone of a strong and growing middle class and a pathway for many out of poverty. U.S. manufacturing could be revitalized by building cutting-edge products and materials with clean, safe, and efficient industrial processes. A comprehensive national commitment to sustainably manufacture the next generation of energy, transportation, and other technologies in the United States will fully capture the benefits to workers and communities.

Clean Air, Clean Water, Safe and Healthy Workplaces and Communities: Tackling climate change goes hand in hand with ensuring that all workers and communities have access to clean air and water. We must also guarantee that our workplaces and communities are safe, clean, and free of hazardous chemicals and toxic pollution. This must include stepping up workplace protections and improving our industrial infrastructure through improved process safety and investments in inherently safer technologies.

Equity for Marginalized Communities: Generations of economic and racial inequality have disproportionately exposed low-income workers, communities of color, and others to low wages, toxic pollution, and climate threats. We must inject justice into our nation's economy by ensuring that economic and environmental benefits of climate change solutions support the hardest hit workers and communities. Special attention must be given to the industries and communities that are most likely to be impacted by the effects of climate change and the transition to a clean economy.

Fairness for Workers and Communities: Working people should not suffer economically due to efforts to tackle climate change. The boldness of any plan requires that the workers and communities impacted are afforded a just and viable transition to safe, high-quality, union jobs. We must also maintain a focus on reducing environmental burdens, continuing to be stewards of our air, water, and lands, and deploying technologies that are safe, as well as effective.

Promote Inclusive Public Dialogue: Workers and communities must have a central role in framing the problem and developing solutions to address climate change. Public dialogue between workers, employers, and governments should be present at all levels, from policy design to implementation and the measurement of results. Representatives of organized labor, community-based groups, and business associations should participate actively and equitably in dialogue at the enterprise, sectoral, and national levels to assess opportunities and resolve challenges posed by the climate transition.

Policies

Greenhouse Gas (GHG) Emissions Reductions: To avoid the catastrophic consequences of climate change, we must significantly reduce the pollution that causes it. Doing so can and should benefit working people and communities across the country. As such, America must commit to implementing the following:

- Rapid GHG emissions reductions—based on the latest science and in line with our fair share—which would put America on a pathway of reducing its emissions to net zero emissions by 2050. The urgency required to stave off the worst impacts of climate change requires that by 2030 we are solidly on a path to net zero emissions;
- Deploy clean and renewable technology nationwide. Low-and-no carbon electricity production; carbon capture, removal, storage, and utilization; natural ecosystem restoration; and zero carbon transportation options are important parts of the solution;
- Make massive immediate investments in energy efficiency across all sectors;
- Utilize continual scientific review to inform and refine our progress; and
- Recommit to achieving our emissions reduction pledges under the Paris Agreement, and to restoring American leadership in global negotiations going forward.

Infrastructure and Community Resilience: Our nation must move forward with an ambitious plan to rebuild and transform America's infrastructure. If we do it right, we will boost our economy, create millions of jobs, and strengthen the resilience of our communities in their ability to prepare and respond to climate related disasters, while also reducing pollution and combating climate change. Strategic investments in infrastructure and a well-trained workforce—including significant investments in revitalizing our public sector workforce—can further ensure that our infrastructure and communities are prepared for the impacts of climate change and the challenges of the next century. Federal, state, and local governments play a crucial role in planning and leading our transition to a cleaner economy while responding to the growing threats of climate change.

Our plan must include:

- Ambitious and strategic public investments to rebuild and modernize America's infrastructure and make our communities more resilient—repairing our failing roads and bridges, replacing lead pipes and upgrading our water systems, stopping fugitive emissions from existing natural gas distribution pipelines, modernizing our schools, increasing the energy efficiency of new and existing buildings in all sectors from commercial to residential to hospitals and universities, expanding and modernizing our electric grid, building clean and affordable transportation systems, and redeveloping brownfields and cleaning up hazardous waste sites;
- Investment in the revitalization and expansion of the public sector workforce and ensuring staffing levels are sufficient to accomplish clean energy, resilience, adaptation, and crisis response objectives;
- Robust investments in natural infrastructure, including improving climate resilience through natural defenses that act as carbon sinks, recovering America's wildlife, restoring forests and wildlands, reclaiming mines, and addressing the public lands maintenance backlog;
- Vigorous investment in broadband networks to close the digital divide, achieve universal access to high-speed Internet, and full utilization of the federally backed FirstNet network for first responders;
- Adaptation, resilience, and pre-disaster mitigation policies and investments, including sustainable land-use, housing, transportation, and natural infrastructure investments that are equitable, community-driven, and designed to uplift rather than uproot communities;
- Targeted policies and investments to communities with the most need and engaging local organizations to advocate, plan, and sustain positive development outcomes; and
- Prioritization of the use of the most efficient, resilient, and cleanest materials and products with the lowest carbon and toxicity footprints.

Competitiveness, Strength, and Innovation: The economic strength of our country has long been connected to the well-being of the middle class. Yet, we can't ensure prosperity if we've fallen behind the rest of the world in building the technologies of the future, and if working people and communities don't see the gains from innovation and a cleaner economy. We need an aggressive agenda to regain American leadership in clean technology innovation, deployment, manufacturing, and good job creation. We can rebuild American competitiveness in the global economy, and secure and create a new generation of good, middle-class jobs across America through:

- A national strategy to lead in clean and emerging technology production and supply chain development, including major investments in domestic advanced technology manufacturing and innovation, penalizing offshoring, and a commitment to at least doubling funding of clean technology research, development, manufacturing, and deployment;
- Application of strong Buy American and Davis-Bacon requirements, as well as utilization of project labor agreements, for all public spending, and procurement policies that ensure the use of domestic, clean, and safe materials made by law-abiding corporations throughout the supply chain;
- Environmentally, economically, and socially responsible mining projects and effective recycling initiatives for strategic materials necessary for a clean energy future;

- Investment in efficient domestic materials production and innovation to greatly limit the emissions associated with energy intensive manufacturing;
- Closing the carbon loophole and stopping the leakage of jobs and pollution overseas through procurement standards, sound trade enforcement, and border adjustments; and
- Ensuring trade agreements are enforceable, fair for all workers, and benefit the environment, including the climate.

High-Quality Job Creation and Retention: American workers have faced wage stagnation, difficult working conditions, and a wholesale effort to decimate their ability to organize for the past several decades. Unionization offers the best pathway for quality jobs and more importantly a good, family-sustaining livelihood. A commitment to high-quality job creation across all sectors of the economy—but especially related to clean energy, adaptation, and resilience—will only be realized if we commit to:

- Increasing union density across the country through strong support of the right to organize throughout the economy, including in the clean technology sectors;
- Remove policy barriers to organizing and promote productive policies to ensure that workers have a meaningful voice on the job;
- Applying mandatory labor standards that include prevailing wages, safety and health protections, project labor agreements, community benefit agreements, local hire, and other provisions and practices that prioritize improving training, working conditions, and project benefits. This includes respect for collective bargaining agreements and workers' organizing rights such as neutrality, majority sign-up, and first contract arbitration for construction, operations, and maintenance;
- Raising labor standards in the non-construction sectors through improved wages and benefits and the prioritization of full-time work that eliminates the misclassification of employees and misuse of temporary labor;
- Investing in training, equipment, preparedness, plan development, and other tools including through registered apprenticeship programs to ensure a robust, skilled, and well-prepared workforce to address the extreme weather events and other impacts caused by climate change; and
- Maximizing the utilization and support for established training providers (such as registered apprenticeships, community colleges, and union training centers) and skill certifications for manufacturing.

Equity, Responsibility, and Safe and Healthy Communities: Justice and equity are critical aspects of any effective climate plan. We must utilize our collective power to solve climate change in ways that lift up all people and make every community more resilient against the impacts of climate change as well as changes in the economy. We must also make sure through this plan that communities are made safer and healthier. As such, America must commit to just solutions through:

- Community benefit, workforce, and other similar agreements that improve access to jobs and career paths, and identify and implement mechanisms to ameliorate and improve local economic and environmental impacts;
- Direct reduction of hazardous waste, toxic chemical emissions, particulate matter, and other non-GHG pollutants across the country, but first and foremost in frontline communities;
- Addressing cumulative environmental impacts that burden frontline communities with disproportionate air, water, and land pollution and climate risks;

- Improve the safety of our industrial facilities and protect workers, first-responders, and fence-line communities;
- Taking steps to avoid creating a "low-carbon, high-toxicity" economy, including reducing our toxicity footprints through investment and innovation in green chemistry;
- Ensuring that frontline communities and workers have equitable access to energy efficiency savings and clean, affordable energy, water, and transportation choices;
- Ironclad commitments to safe and healthy working conditions; and
- A recognition of our country's opportunity and responsibility to help fund a clean energy economic development model for developing and emerging countries, including the transfer of technologies and capacity building, as well as assisting vulnerable developing countries in coping with the mounting impacts of climate change through ramped-up investments in adaptation and resilience strategies.

Fairness to Workers and Communities: America lacks a decent support system for people who have fallen through the cracks in our economy. Solutions that rely on or fail to address these systems are doomed to create new problems and ensure that America lags behind in the global race for a prosperous 21st century economy. As such, the United States must establish a globally competitive social safety net, including:

- Effective and equitable access to high-quality employment, training, and advancement for all workers, particularly those from low-income households, those historically under-represented on the basis of race, gender, and other criteria, and those adversely impacted or dislocated by technological change—notably including those in energy, transportation, and trade impacted communities;
- Guaranteed pensions and a bridge of wage support, healthcare, and retirement security until an impacted worker either finds new employment or reaches retirement;
- Dedicated community engagement including workers, community members, and leaders to support and enhance the development of the local economy;
- Massive economic investment in deindustrialized areas, including remediating any immediate loss of tax base or public services for communities;
- Mandated reclamation of closed and abandoned industrial sites to remediate deindustrialized blight, coupled with economic development and diversification; and
- Requirements for fair and safe working conditions throughout global supply chains.

BLUEGREEN ALLIANCE

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July 24, 2019

The Honorable Paul Tonko	The Honorable John Shimkus
Chairman	Ranking Member
Subcommittee on Environment & Climate Change	Subcommittee on Environment & Climate Change
U.S. House of Representatives	U.S. House of Representatives
2123 Rayburn House Office Building	2123 Rayburn House Office Building
Washington, D.C. 20515	Washington, D.C. 20515

Dear Chairman Tonko and Ranking Member Shimkus:

Decarbonizing our economy will be a huge challenge. Nuclear energy, which is our largest source of emissions-free power, must play a big role in solving the problem, and prompt actions now can give us a leg up on reaching our goal of climate stabilization.

Several studies have shown that decarbonizing with nuclear energy significantly reduces the cost. For example, a recent study by several MIT experts found, "Across a wide range of sensitivities, firm low-carbon resources—including nuclear power, bioenergy, and natural gas plants that capture CO2—consistently lower the cost of decarbonizing electricity generation. … Availability of firm low-carbon technologies, including nuclear […], reduces electricity costs by 10%–62% across fully decarbonized cases."[1]

America's 98 power reactors provide nearly 20 percent of our electricity. Nuclear power also represents over 50 percent of all the clean, carbon-free electricity in the U.S. That's more than twice the amount of wind and solar combined. That much carbon-free electricity is the equivalent of retiring over 100 million passenger cars.

And this nuclear carbon-free electricity is created very efficiently. There are 8,000 power plants connected to the grid, and less than one percent of them are nuclear plants.

[1] "The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation," by Nestor A. Sepulveda, Jesse D. Jenkins, Fernando J. de Sisternes, and Richard K. Lester, *Joule*, November 21, 2018.

The problem today is that some of these nuclear plants are operating in energy markets that are poorly structured and do not recognize the value of emissions-free energy. As a result, some plants have closed and others are threatened. The ones we have lost, and are poised to lose, will take many years and billions of dollars to replace with new emissions-free generators. Replacing just one, 1,000-MW nuclear reactor would require an investment of nearly $3 billion to site 937 wind turbines or $5 billion for 18.5 million solar panels.

Many of our nation's nuclear plants are facing a decision whether to apply for extensions on their operating licenses. These major capital assets can be run safely for decades more, but they will require investment and modernization. Keeping them operating also provides benefits beyond climate. It keeps the electric system reliable and moderates price swings, and provides well-paid, year-round employment.

The nuclear energy industry supports 475,000 American jobs. The industry contributes $60 billion to the country's GDP. And it pays $10 billion in federal and $2.2 billion in state taxes each year.

The federal government should take steps to preserve the nuclear fleet and extend its life.
The other short-term step is to encourage the commercialization of new reactor technologies. In coming years, we are likely to begin an accelerated effort to decarbonize, and now is the time to establish what works and what needs refinement. New nuclear reactors have other economic benefits: They provide very substantial construction employment and permanent jobs for high-skilled, high-wage operators and maintenance personnel. They pay the taxes that fund our schools and our towns.

Government can be a lender, and a customer for the clean electricity these plants will produce. Government regulators must continue their vigilant, independent safety regulation, while continuing to modernize their rules to take account of new designs.

We cannot know today the details of what a low-carbon economy will look like, but we do know that it will be mostly electric.

A strong nuclear backbone in our electric system is important now and will become more so in the future, because the vast quantities of low-carbon energy that reactors produce makes everything else work better, too. Electric cars, which the government is subsidizing heavily, are only as clean as the electricity that goes into them. That means putting nuclear on the grid. Electric heat pumps that displace fuel oil and methane in home heating likewise need clean electricity to justify their expense. And beyond electricity, steam from new nuclear plants can replace fossil fuels in oil refineries and other industrial uses. These will be mostly new designs. American ingenuity is up to the challenge of designing these machines, and American labor is ready to build and operate them.

The IBEW and the nuclear industry look forward to being a major part of the campaign for climate stability. Our jobs, environment and economy demand it.

Yours very sincerely,

Lonnie R. Stephenson
International President
International Brotherhood of Electrical Workers

Maria Korsnick

Maria Korsnick
President and CEO
Nuclear Energy Institute

c: The Hon. Frank Pallone, Chairman, Committee on Energy and Commerce
The Hon. Greg Walden, Ranking Member, Committee on Energy and Commerce
Members of the Committee on Energy and Commerce

THE CHANGING **NUCLEAR NARRATIVE** 2018

In 2018, the nuclear energy industry saw a significant shift in the nuclear narrative, with editorials of support from major media outlets and a chorus of third parties—including historically adversarial organizations—publicly supporting efforts to preserve the existing fleet. Here are some examples:

Bloomberg

JAN. 10

- **Bloomberg** editorializes that "Another strategy is for states to expand their renewable portfolio standards—which require that a certain proportion of power come from renewable sources—to make them low-carbon portfolio standards, hence taking in nuclear as well as wind, solar and hydropower."

grist

JAN. 12

- Commentary in **Grist Magazine**, an environmental news publication, suggests that climate change cannot be solved without nuclear power and says a shift in attitude toward nuclear is needed "to prevent us from going over the climate cliff." The piece concludes with "if we are smart, we'd see nuclear power for what it is: A good bet to save the world."

Vox

APR. 5

- Dave Roberts, an influential writer at the left-leaning news outlet **Vox**, writes that the nation's biggest energy market, PJM, may lose five nuclear reactors in the next few years, larger than all the region's wind and solar combined. "If climate change is indeed an existential threat," Roberts asks, "isn't the loss of 40 TWh a year of carbon-free energy a four-alarm emergency?"

JUN. 26

- A group of **77 industry leaders, U.S. statesmen, retired flag officers, generals, national security officials** sends a letter to Secretary Perry, endorsing nuclear energy's national security importance and urging him "take concrete steps to ensure the national security attributes of U.S. nuclear power plants are properly recognized by policymakers and are valued in U.S. electricity markets."

NRDC SIERRA CLUB

OCT. 1

- **Natural Resources Defense Council and Sierra Club** join NEI and others in a filing with the Federal Energy Regulatory Commission asking the commission to "preserve states' ability to achieve clean energy policy goals," including Zero-Emission Credit programs.

UNITED NATIONS

OCT. 7

- **United Nations' Intergovernmental Panel on Climate Change** predicts severe effects of climate change coming by 2030 and identifies nuclear as one of the technologies necessary to hold warming to 1.5 degrees C.

Google

OCT. 10

- **Google** publishes a white paper on progress toward its data centers using 24x7 carbon-free electricity and acknowledges that nuclear provides a large share of the grid's carbon-free energy. "Data centers that perform well on the metric of 24x7 carbon-free energy are often located in regions that have a substantial amount of carbon-free energy already on the grid," Google reports. "Accordingly, it's important for governments, utilities, and other energy market players to carefully consider retirement of existing firm carbon-free generation."

@NEI NuclearEnergyInstitute NEI NUCLEAR ENERGY INSTITUTE

THE CHANGING **NUCLEAR NARRATIVE** 2018

MacArthur Foundation

OCT. 12 • **President of the MacArthur Foundation Julia Stasch** co-authors an op-ed with Exelon President and CEO Chris Crane that calls for actions to address the climate challenge, which includes "the use of safe and secure nuclear power." They agree that the climate is changing quickly and the nuclear fleet must be maintained.

The Nature Conservancy

OCT. 15 • **The Nature Conservancy** releases its Science of Sustainability study, which concludes that if the world is to meet what it calls the Sustainable path by 2050, nuclear needs to provide one-third of all global energy. TNC also notes that eliminating nuclear energy would have a large land impact "requiring an additional 245 million ha for energy production in 2050." Notably, 245 million hectares is larger than 185 of the countries recognized by the UN.

Union of Concerned Scientists

NOV. 7 • **Union of Concerned Scientists** issues "The Nuclear Power Dilemma: Declining Profits, Plant Closures and the Threat of Rising Carbon Emissions." UCS acknowledges the impact that nuclear plant closures have on climate and air quality and advocates for policies to preserve financially struggling nuclear plants. In a blog post about the report, UCS President Ken Kimmel writes it's important "that we keep an open mind about all of the tools in the emissions reductions tool box — even ones that are not our personal favorites."

The Boston Globe

NOV. 10 • Covering the UCS report, a **Boston Globe** editorial endorsed taking action to support nuclear plants and says "the potential to lose those resources could undo the nation's recent progress in reducing its greenhouse gas emissions."

Our clean energy future depends on keeping nuclear plants online and building new reactors at home. More are valuing nuclear for what it is: the largest carbon-free source of electricity in America, and the only one that runs 24/7. Find out more at **nei.org/preserve.**

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Nuclear Energy

Essential Clean Energy for a Low-Carbon Economy

BACKGROUND

A consensus is forming that as important as renewables are to reduce carbon emissions, achieving a 100 percent clean, carbon-free energy system requires a mix of fuels. We should encourage all zero-emissions technologies in the clean energy policies designed to achieve carbon-reduction goals. Nuclear power—the nation's largest source of carbon-free electricity—is an essential part of the U.S. clean energy portfolio.

KEY POINTS

Experts urge policies to decarbonize the energy sector to fight climate change. The 24/7 clean energy that nuclear provides is essential to meet climate and clean energy goals.

- The United Nations International Panel on Climate Change predicted in October 2018 severe effects of climate change by 2030 and identified nuclear as one of the technologies necessary to hold warming to 1.5 degrees Celsius.
- The Union of Concerned Scientists acknowledged in November 2018 the impact that nuclear plant closures have on climate and air quality, embracing the idea of implementing policies to preserve financially struggling nuclear plants.

Nuclear energy is critical to decarbonize the energy sector and the loss of current nuclear energy will set us significantly backward in our nation's effort to reduce carbon emissions.

- In 2017, nuclear energy generated 20 percent of U.S. electricity and 56 percent of our emissions-free generation, more than all other sources combined.
- Twelve nuclear units have been announced for closure, which combined produce 90 million megawatt-hours (MWh) each year or as much residential electricity used in California in 2017.
    - 90 million MWh of lost clean energy is more than all solar generation in the United States and more than all wind generation to the east of the Mississippi River in 2017.
- A single nuclear plant produces as much emissions-free electricity as it took to power all electric vehicles in the United States in 2017.

We must take a technology-neutral approach to clean, carbon-free energy.

- According to research from Harvard University, Massachusetts Institute of Technology, and the Organization for Economic Cooperation and Development, powering the grid with 100 percent renewables isn't the most affordable way to create a zero-carbon grid. Instead, the best way to eliminate emissions from the grid is by combining intermittent low-carbon sources, such as wind and solar, with one or more "firm" sources, such as nuclear energy.

Actions must be taken to preserve nuclear plants.

- Beginning in 2016, states began taking action to preserve their nuclear generating capacity in order to constrain carbon emissions. These states include Illinois, New York, Connecticut and New Jersey. Similar legislative action will be under consideration in Pennsylvania and Ohio.
- In October 2018, Google published a white paper that warned "governments, utilities, and other energy market players carefully consider retirement of existing firm carbon-free generation," including nuclear power.

A CLEAR CONSENSUS:

NUCLEAR ENERGY MUST BE PART OF ANY CLIMATE SOLUTION

The urgency to rapidly reduce carbon emissions is growing each day. In response, important voices and organizations focused on climate change have come to a clear consensus that nuclear energy is essential for timely decarbonization. Their recent analyses show that nuclear energy must be preserved to enable policymakers to curb emissions.

The bottom line: Without nuclear energy, we cannot achieve our climate goals.

July 3, 2019

BloombergNEF

Michael Liebreich, founder and senior contributor to BloombergNEF, Bloomberg's primary research service, argues that **"wind and solar alone can't provide enough zero-carbon power to decarbonize the economy in the near term"** and that **"the overwhelming priority is to keep existing nuclear plants open."**

June 29, 2019

ReNew POWER

Varun Sivaram, chief technology officer of ReNew Power, India's largest renewable energy company, participates in a panel at the Aspen Ideas Festival and states, **"Taking any option to reduce carbon emissions off the table, including nuclear power, is morally reprehensible."**

June 10, 2019

WORLD RESOURCES INSTITUTE

World Resources Institute's Senior Fellow John Woolard argues that commitments to 100 percent renewables cannot solely achieve the system change needed to avoid the worst impacts of climate change. Woolard says it's time for companies and countries to commit to 100 percent zero-carbon energy and highlights the essential role of nuclear, stating, **"The imperative of climate change means we must look at options to continue to build nuclear power in the United States."**

June 5, 2019

pjm

PJM Interconnection, the regional transmission operator that manages a competitive wholesale electricity market in 13 states and Washington, D.C., issues a report to assess the impacts of preventing the closure of three nuclear plants in Ohio and Pennsylvania. The report finds that **preserving the Beaver Valley, Perry and Davis-Besse nuclear plants would reduce electricity costs by $474 million and save more than 15 million tons of carbon dioxide.**

SEE MORE

NEI NUCLEAR ENERGY INSTITUTE

@NEI NuclearEnergyInstitute

May 28, 2019

iea International Energy Agency

The IEA releases “Nuclear Power in a Clean Energy System,” a report that finds that without policy changes, advanced economies could lose 25 percent of their nuclear capacity by 2025 and as much as two-thirds of it by 2040. The lack of further lifetime extensions of existing nuclear plants and new projects could result in an additional 4 billion tons of carbon dioxide emissions. **“Without an important contribution from nuclear power, the global energy transition will be that much harder,”** said Dr. Fatih Birol, the IEA’s executive director.

May 28, 2019

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Based on a year-long collaboration with leading companies including Microsoft and Mars Inc., C2ES outlines alternative scenarios for decarbonizing the U.S. economy. Its report ,“Pathways to 2050: Alternative Scenarios for Decarbonizing the U.S. Economy,” identifies three scenarios that take a technology-neutral approach, showing **nuclear energy has a key role to play in achieving 80 percent decarbonization.**

May 20, 2019

Atlantic Council

The Atlantic Council Task Force on U.S. Nuclear Energy Leadership finds nuclear is necessary not only for national security, but for reaching global climate goals as well. Its report, “U.S. Nuclear Energy Leadership: Innovation and the Strategic Global Challenge,” states, **“From a foreign-policy perspective, U.S. technological leadership and the credibility of the nation’s nuclear capabilities allow the United States to present a viable, carbon-free option to countries intent on addressing their energy demand and security needs while also meeting climate goals.”**

April 6, 2019

The New York Times

In an op-ed in The New York Times titled “Nuclear Power Can Save the World,” authors Joshua S. Goldstein and Staffan A. Qvist state, **“Climate scientists tell us that the world must drastically cut its fossil fuel use in the next 30 years to stave off a potentially catastrophic tipping point for the planet. Confronting this challenge is a moral issue, but it’s also a math problem—and a big part of the solution has to be nuclear power.”**

Feb. 6, 2019

Breakthrough Energy

The report “Advancing the Landscape of Clean Energy Innovation” by the Breakthrough Energy Coalition finds that **“providing for a nuclear energy option, both nationally and globally, to provide clean, dispatchable baseload and scalable power in a complex and dynamic power grid environment is a critical goal.”**

Subcommittee on Environment and Climate Change
Hearing on
"Building America's Clean Future: Pathways to Decarbonize the Economy"
July 24, 2019

Dr. Karl Hausker
Senior Fellow, Climate Program
World Resources Institute

The Honorable Paul Tonko (D-NY)

1. Policy can play an important role in driving technology development and deployment, especially when it corrects market failures and creates investment certainty. Potentially effective policies may include those which send a price signal to the private sector. For our purposes, "price signal" can be interpreted broadly, from a direct carbon pricing program to an indirect price, for example the 45Q tax credit.

   a. Do you believe that sending a clear price signal on carbon pollution as part of comprehensive legislation would help support greater energy innovation and clean energy technology deployment?

   RESPONSE:

   Absolutely, yes. A carbon price is needed to incorporate climate change costs into economic decision-making to significantly reduce greenhouse gas emissions in the U.S. and in other countries. It would spur both deployment and innovation. However, a carbon price is not a silver bullet for addressing climate change. Complementary policies to a carbon price are also needed. These policies and programs must address market barriers and drive deep emissions cuts over the long-term.

   WRI just released a relevant Issue Brief titled "Putting a Price on Carbon: Evaluating A Carbon Price and Complementary Policies for a 1.5° World" (https://www.wri.org/publication/evaluating-carbon-price). This issue brief is the latest in WRI's series "Getting Serious About Carbon Pricing." The full series is available at https://www.wri.org/our-work/project/getting-serious-about-carbon-pricing/publications.

Subcommittee on Environment and Climate Change
Hearing on
"Building America's Clean Future: Pathways to Decarbonize the Economy"
July 24, 2019

Ms. Shannon Angielski
Executive Director
Carbon Utilization Research Council

The Honorable Paul Tonko (D-NY)

1. Policy can play an important role in driving technology development and deployment, especially when it corrects market failures and creates investment certainty. Potentially effective policies may include those which send a price signal to the private sector. For our purposes, "price signal" can be interpreted broadly, from a direct carbon pricing program to an indirect price, for example the 45Q tax credit.

    a. Do you believe that sending a clear price signal on carbon pollution as part of comprehensive legislation would help support greater energy innovation and clean energy technology deployment?

    RESPONSE: CURC does not take a position on carbon pricing. Rather, members of CURC will evaluate the ability of technology to compete under any proposed carbon pricing scenario, and will inform policymakers regarding the ability of carbon capture and other technologies to be effectively developed and deployed under proposed scenarios. With regards to carbon pricing, CURC encourages policymakers to value a variety of attributes necessary for our electric generation system to be efficient and effective. For example, while low to zero carbon may be a key objective under a carbon pricing system, it is important that such a system place an equal value on the ability of low to zero carbon electricity to be dispatched on demand, and on the need for such generation to be resilient against any potential disruptions.

The Honorable Markwayne Mullin (R-OK)

1. You point out in your testimony that: globally, oil and natural gas consumption will increase to more than double their consumption rates today. Is that because renewable energies like solar and wind are more expensive and less abundant?

    RESPONSE: CURC used the U.S. Energy Information Administration's projections for base case growth in the testimony we submitted to the Committee. The EIA's analysis indicates that the increased use of fossil fuels is a direct result of the combined gross domestic product (GDP) in the countries that are not part of the Organization of Economic Cooperation and Development (OECD), which grows by 3.8% per year on average between 2018 and 2050, compared with 1.5% per year in

the OECD countries. In EIA's international forecasts, most increases in energy consumption come from non-OECD countries, where strong economic growth, increased access to marketed energy, and rapid population growth lead to rising energy consumption.

The industrial sector, which includes refining, mining, manufacturing, agriculture, and construction, accounts for the largest share of energy consumption of any end-use sector—more than 50% of end-use energy consumption during the entire projection period. The industrial sector is largely powered by fossil fuels. EIA analysis indicates that coal continues to be an important end-use fuel in industrial processes, including the production of cement and steel.

Although EIA projects that renewable energy is the world's fastest growing form of energy, fossil fuels continue to meet much of the world's energy demand. Natural gas contends as the world's fastest growing fossil fuel, increasing by 1.1% per year, compared with liquids' 0.6% per year growth and coal's 0.4% per year growth. However, IEA projects that coal use is on the rise in Asia, as a result of increased industrial usage and rising use in electric power generation in non-OECD Asia and China.

a. What can the United States do to ensure we are reducing the cost of carbon capture technologies?

   RESPONSE: Today's CCUS technologies are still at the early stages of deployment and relatively expensive to implement in some industries like the power sector. Like the wind and solar industries that were just emerging 15 years ago, a combination of federal incentives such as tax credits and federal funding for research, development, demonstration will be needed to improve the performance of the technology, which will reduce the costs of implementation so it can be deployed in commercial markets. Federal funding to support private sector research, development and demonstration activities are necessary to accelerate the development and commercial application of CCUS across a variety of industries. Such a program is necessary to compliment other federal and state policies that will enable a CCUS industry.

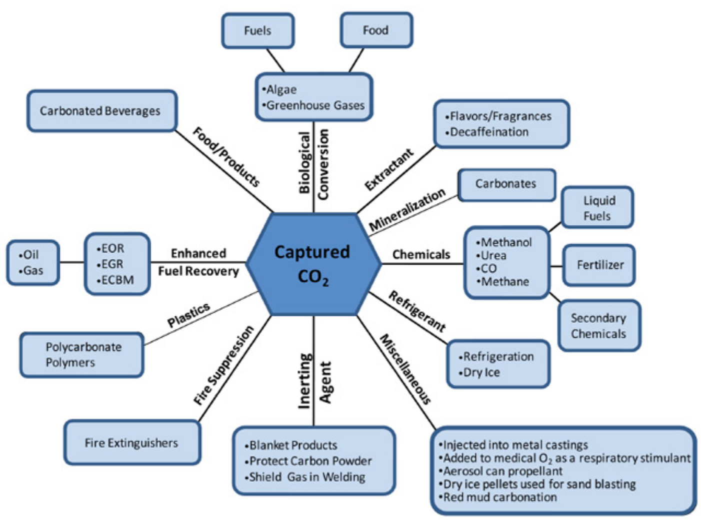
   There are novel fossil energy power cycles in development that are designed to facilitate the capture of CO_2 at a lower energy penalty and cost than conventional methods. These processes are inherently more efficient, resulting in fewer emissions of both CO_2 and criteria pollutants, and require less fossil fuel to be used to produce electricity. Recent advances in carbon capture technologies will lower costs, and the development and testing of these technologies at test centers such as the Wyoming Integrated Test Center and the National Carbon Capture Center in Alabama will help in the scale up and commercial deployment of carbon capture.

Ms. Shannon Angielski, Executive Director
Carbon Utilization Research Council
Page 3

Many of these technologies are readying for pilot testing now and a few are preparing for commercial-scale demonstration. It is critical that federal policies support not only R&D, but also the piloting and demonstrating of these innovative, first-of-a-kind technologies. This means annual federal budgets should increase in the next several years to support the scale-up effort.

b. Most discussions of Carbon Capture talk about using CO2 for enhanced oil recovery and storage. Can you describe some of the other "Utilizations" in Carbon Capture Utilization and Storage? And how do we make it profitable?

RESPONSE: There are niche opportunities to convert CO_2 into other products, including chemicals, fuels and cement. The graphic below illustrates the current and potential uses of CO_2. However, many of these uses are small scale and do not result in large CO_2 emissions reductions. Some of the more significant current and potential uses of CO_2 are highlighted in the research underway in this focus area.



Subcommittee on Environment and Climate Change
Hearing on
"Building America's Clean Future: Pathways to Decarbonize the Economy"
July 24, 2019

Mr. Armond Cohen
Executive Director
Clean Air Task Force

The Honorable Paul Tonko (D-NY)

1. Policy can play an important role in driving technology development and deployment, especially when it corrects market failures and creates investment certainty. Potentially effective policies may include those which send a price signal to the private sector. For our purposes, "price signal" can be interpreted broadly, from a direct carbon pricing program to an indirect price, for example the 45Q tax credit.

    a. Do you believe that sending a clear price signal on carbon pollution as part of comprehensive legislation would help support greater energy innovation and clean energy technology deployment?

    RESPONSE: Yes

The Honorable Markwayne Mullin (R-OK)

1. In your testimony, you note the environmental impact of methane emissions from flaring excess natural gas at drill sites. Would you agree that we need to create more natural gas pipelines to ensure that it does not go wasted and we efficiently use our resources?

    RESPONSE:

    There is a need for development of oil and gas production to be properly planned and managed so that gas production does not outpace the capacity of pipelines to take gas to market or re-inject it. Because of the steep declines in production from modern tight wells, proper planning approaches could rapidly reduce flaring. Additionally, operators have other means to use gas beneficially when pipelines are not available, such as trucking compressed natural gas, removing natural gas liquids onsite, and generating electricity onsite for use on the well-pad or nearby. These technologies cannot replace properly planned gas gathering systems, but they can be useful for filling gaps if problems arise in gathering systems, etc., and they have been recognized as an appropriate means to reduce flaring (for example, by the North Dakota Industrial Commission). Carbon Limits, "Improving Utilization of Associated Gas in US Tight Oil Fields" (2015) Available online at: http://www.catf.us/wp-content/uploads/2015/04/CATF_Pub_PuttingOuttheFire.pdf

a. You mention the need to use all of our available "tools in the tool chest," if you will. However, you fail to mention Renewable Natural Gas which turns biomethane from agricultural, food, landfill, or wastewater into fuel for Natural Gas Vehicles. Are you aware that over the last 5 years, RNG use as a transportation fuel has increased 577%, displacing 7 million tons of carbon dioxide equivalent?

RESPONSE:

The Clean Air Task Force is aware that the use of RNG has increased substantially in recent years, and that the environmental benefits of using RNG to displace fossil fuels can be substantial.

b. Would you agree that renewable natural gas vehicles play a part in reducing our carbon pollution?

RESPONSE:

Biogas emissions from farms, landfills, wastewater treatment plants, and other sources contribute significantly to global climate change and should be reduced or eliminated wherever possible. Although the extent to which RNG utilization can reduce overall atmospheric greenhouse gas levels is constrained by scalability challenges (*e.g.*, aggregating biogas from multiple small farms spread across a large area is difficult), capturing biogas and upgrading it to RNG can nonetheless be a useful strategy for mitigating the environmental threat posed by biogas emissions and reducing carbon pollution from the energy and transportation sectors. A 2018 study conducted by Stanford University identifies the displacement of diesel by RNG in medium- and heavy-duty vehicles as likely being the most environmentally-beneficial use of RNG; the study also finds that "[r]eplacing just 16% of the conventional natural gas utilized in California with RNG would achieve the same amount of greenhouse gas reductions as electrifying 100% of the state's buildings." (Maritza Correa *et al*. "Renewable Natural Gas: Insights and Recommendations for California." TomKat Center for Sustainable Energy. Stanford University, August 2018, https://stanford.app.box.com/s/6lfnipidxeoeuc4ix4rwg1xz7w0m8tdq.)

Subcommittee on Environment and Climate Change
Hearing on
"Building America's Clean Future: Pathways to Decarbonize the Economy"
July 24, 2019

Dr. Rachel Cleetus
Policy Director, Climate and Energy Program
Union of Concerned Scientists

The Honorable Frank Pallone, Jr. (D-NJ)

1. As the Committee considers policy options that will enable the United States to reach net zero emissions by 2050, we recognize the critical importance of ensuring a just transition for impacted communities. In your experience, looking at best practices at in the United States or internationally, what measures ought to be incorporated into climate legislation to guarantee a just transition for these communities?

RESPONSE:
Over the last decade, coal has grown increasingly uneconomic relative to cleaner forms of power generation and that has led to numerous coal company bankruptcies, with painful consequences for coal mining families and communities that are economically dependent on coal. As we implement policies to transition the US economy to net zero emissions by 2050, we must do what is right and fair to help protect the well-being of these workers and communities. The BlueGreen Alliance's Solidarity for Climate Action platform lays out some core principles and priorities for how to do this.

UCS strongly supports:

(i) Measures to ensure that existing commitments to coal miners and other coal-dependent workers—including pensions and medical benefits—are honored. This would include making sure that companies are not allowed to step away from these commitments via bankruptcy proceedings, and that Congress does its part to ensure the continued solvency of pension plans and the Black Lung Disability Trust Fund.

(ii) Legislation to provide funding and capacity building for unemployment and medical benefits to displaced workers for up to five years, worker retraining and job placement programs, economic diversification programs, and temporary aid to make up for local tax revenue shortfalls for coal-dependent communities.

(iii) Legislation and regulations to ensure clean-up and remediation of legacy pollution from coal mining and coal-fired power plants, including toxic pollutants such as those present in coal ash. Companies should not be allowed to evade their responsibilities to communities who bear the health burden of these harmful pollutants.

(iv) Direct Engagement with local communities affected by our current dependence on fossil fuels and the ongoing transition away from them to help develop solutions that they want and need.

Recent examples to draw from include:

- Colorado recently enacted a just transition bill—the first of its kind in the U.S. It establishes a Just Transition Office within the Colorado Department of Labor and Employment that is tasked with working with an external advisory group to develop an equitable set of plans and policies for coal-dependent communities as the state works to achieve ambitious climate goals. It is the most striking, broad recognition by a state government of the reality facing coal—and Colorado gets about half its electricity from coal.
- The Government of Canada released two reports in 2019 from a task force that made specific recommendations on how to ensure a fair transition for affected coal communities, in the context of the government's commitment to phase out coal by 2030. Though the coal industry is much smaller in Canada, the reports and findings can serve as a model for the U.S.
- Germany's "Commission on Growth, Structural Change and Employment" has developed a series of recommendations for that nation to phase out coal by 2038 in a just and equitable manner, including policies and investments targeted at coal-dependent communities.

2. We sometimes hear that the United States should not take bold action to address climate change until other large countries, namely China and India, have done the same. That argument suggests not only that those countries are failing to act, but that the United States should follow, rather than lead, on the international stage.

    a. Are other large emitting countries, such as China and India, failing to act on climate change?

RESPONSE: Climate change is a global problem and it will require a concerted effort by the entire global community—especially the major emitting nations—to help address it. No one nation, whether it be the US or China or India, can tackle this on its own.

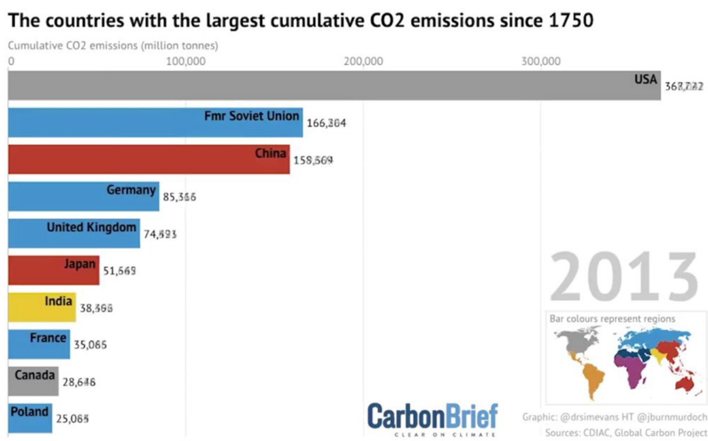
The reality is global emissions are still rising, at a time when they need to fall sharply. According to the IEA, in 2018 global energy-related carbon dioxide emissions were up 1.7% and hit a record high of 33.1 $GtCO_2$.[1] China's emissions grew by 2.5% and US emissions by 3.1%. According to the EIA, US energy-related CO_2 emissions were up

[1] See https://www.iea.org/geco/

2.8% in 2018, the largest increase since 2010.[2] India's emissions rose 4.8 percent in 2018, although it remains well below the world average on a per capita basis.

From a climate perspective, it is cumulative carbon emissions that matter. This figure from Carbon Brief clearly shows the US's leading responsibility for cumulative carbon emissions since the industrial revolution. (Figure 1. See also this accompanying visual: https://www.youtube.com/watch?v=jx85qK1ztAc)

Figure 1:



Clearly, both the US and China—and all major emitting countries—will need to cut emissions significantly if we are to meet our climate goals of limiting global temperature increase to well below 2°C, aiming for 1.5°C. The US can and must play a leadership role. One of the most impactful things we can do is recommit to the Paris Agreement and work hard to implement it in a robust way, in cooperation with other countries including China. Unless we act boldly together, we will fail to meet our climate goals and future generations everywhere will suffer as a result. The urgency of the climate crisis requires that we face this challenge head-on and not retreat to insular ways of thinking.

The US, China and India are all global leaders in renewable energy and there is a huge opportunity to expand the global market in these technologies and create new jobs and economic opportunities in the process. Right now, the policy environment in the US is lagging and putting our nation at a competitive disadvantage. Now is the time to set

[2] See https://www.eia.gov/todayinenergy/detail.php?id=38133

Dr. Rachel Cleetus, Policy Director
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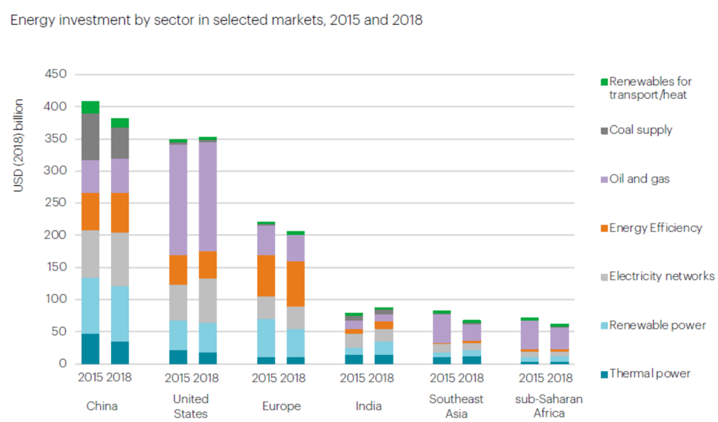
ambitious targets for transitioning to a low-carbon economy and reaping all the economic, health and environmental benefits of doing so.

China is both a global leader in renewable energy deployment and, unfortunately, in coal consumption. The US similarly has seen a big surge in renewable energy over the last decade but 2018 also saw the nation reach new records in the production, consumptions and export of fossil fuels.[3] The government of India has laid out an ambitious goal of 175 gigawatts (GW) of installed renewable capacity by 2022, including 100 GW of solar and 60 GW of wind.[4]

A recent report from the IEA finds that energy investments in China, the US and India show important progress in energy efficiency and renewable energy (see figure 2). In India, in 2018, renewable spending continued to exceed that for fossil fuel-based power for the third year in a row.

Figure 2:

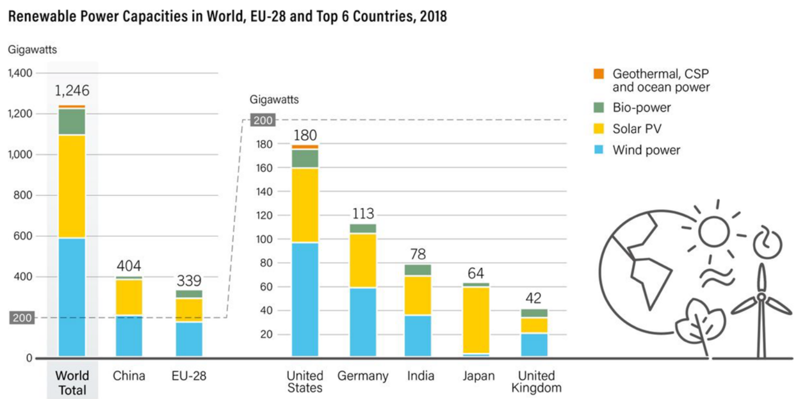


Source: IEA 2019

In 2018, China was responsible for 32% of all new renewable power investments (see figure 3).

[3] See https://www.eia.gov/todayinenergy/detail.php?id=39392
[4] See https://www.nrel.gov/usaid-partnership/energy-goals-india.html

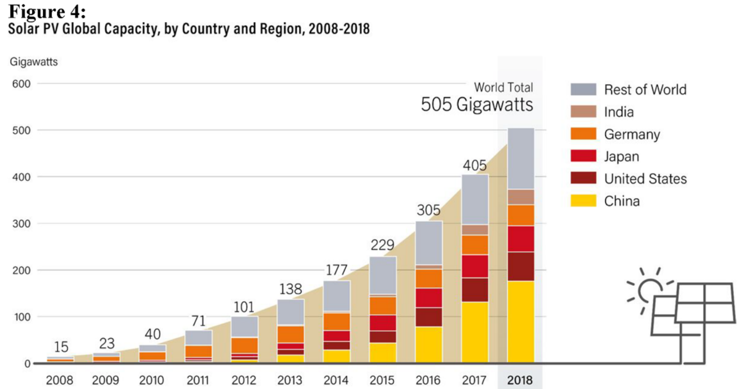
Figure 3:



Source: REN21[5]

China has also led in solar PV installations (see figure 4). India has also made major progress and had a bold commitment on expanding solar power.

Figure 4:

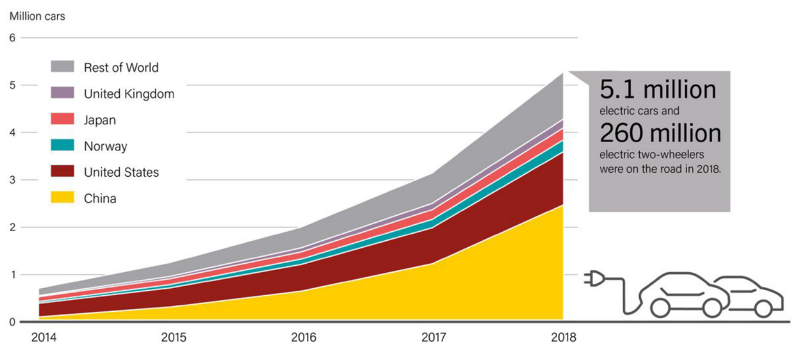


[5] See http://www.ren21.net/gsr-2019/

Source: REN21

China is also leading the world in electric vehicle deployment (see figure 5)

Figure 5:
Electric Car Global Stock, Top 5 Countries and Rest of World, 2014-2018



Source: REN21

b. What are the competitive and diplomatic ramifications of ceding U.S. climate leadership to other countries?

RESPONSE: There is no question that recent actions from the Trump administration—including rollbacks of domestic climate and clean energy policies and the decision to step away from the Paris Agreement—have left the US isolated and on the sidelines of global climate leadership.

As my colleague Alden Meyer put it:

> "President Trump's decision to walk away from the Paris Agreement is irresponsible and shortsighted. All too many people are already experiencing the costly and harmful impacts of climate change in the form of rising seas, more intense hurricanes and wildfires, and record-breaking temperatures. The Paris Agreement is our best hope to mount an effective global response to the climate crisis, which is why it has resounding support from a majority of Americans.
>
> "President Trump's anti-science stance on climate change puts the profits of fossil fuel polluters above the health and well-being of current and future generations. It also impedes the ability of American companies and workers to compete with other countries

like China and Germany in the rapidly expanding market for climate-friendly technologies.

"Fortunately, no other country is following President Trump out the door on Paris, and here at home, states, cities and businesses representing more than half of the U.S. GDP and population have committed to take action to meet the Paris Agreement's goals. Unlike the president, these leaders understand that reducing emissions creates jobs and protects local communities, while it is inaction on climate that poses the real threat to prosperity."

Walking away from the Paris Agreement—an agreement secured after years of painstaking diplomatic work, with the US playing a key role—also sends a signal to the rest of the world that the US cannot be relied upon to live up to its commitments. This has the potential to adversely affect other international negotiations on key issues like trade and security.

c. How can U.S. leadership help motivate other countries to act boldly on climate change?

RESPONSE: US leadership can play a powerful catalyzing force in securing ambitious global action on climate change. US leadership in particular was crucial in laying the groundwork for, and securing, the Paris Agreement.

It's vital that we enact strong federal policies to cut emissions—building on the groundwork laid by states and cities—and help shape the global community's response to one of the most pressing challenges of our time. Our leadership will not only deliver important economic and public health benefits domestically, it can serve as a model to other nations for what policies and technologies hold the greatest promise. In the absence of this leadership, there is a real risk that we will fail to meet global climate goals.

Bold global action is also crucial to help limit the negative effects of climate change on people in the US. Recent UCS research on sea level rise and extreme heat shows clearly that limiting global emissions in line with the goals of the Paris Agreement would greatly curtail those harmful and costly impacts, for example.

The Honorable Paul Tonko (D-NY)

1. Policy can play an important role in driving technology development and deployment, especially when it corrects market failures and creates investment certainty. Potentially effective policies may include those which send a price signal to the private sector. For our purposes, "price signal" can be interpreted broadly, from a direct carbon pricing program to an indirect price, for example the 45Q tax credit.

    a. Do you believe that sending a clear price signal on carbon pollution as part of comprehensive legislation would help support greater energy innovation and clean energy technology deployment?

RESPONSE: Putting a price on carbon is a powerful way to help ensure that the full costs of carbon emissions (i.e. the climate impacts they cause) and the benefits of transitioning to low-carbon energy options are better reflected in our energy production and consumption choices. It can also help drive innovation in low-carbon technologies. UCS supports a well-designed carbon price as part of a suite of climate and clean energy solutions designed to get us to net zero emissions no later than 2050. To work well, the policy must be designed to deliver emission reductions on a scale and timeline that reflects the best available science; it must reflect equity considerations; and it should not be seen as a "silver bullet" solution (i.e. must be paired with other complementary clean energy policies).

Key considerations for a well-designed carbon price:

1. **Robust, science-based carbon price.** A carbon pricing program should be designed to drive down emissions in line with the goals of the Paris Agreement and in keeping with the findings of the IPCC 1.5 report. An economywide carbon price—accompanied by other complementary polices—should aim to put the US on a path to net zero emissions no later than 2050. The price must start at an ambitious level and escalate steadily over time so as to drive deep emission reductions by 2030 (on the order of 45% below 2010 levels, in line with the IPCC report) and continue progress beyond. Providing this time horizon will also give businesses the certainty they need to make appropriate decisions regarding long-lived investments and innovation. Program design should be underpinned by robust environmental, economic, and public health modeling to ensure achievement of program goals and to inform proactive programmatic attention to inequitable distributional economic or co-pollutant impacts.
2. **Broad sectoral coverage.** For greatest effectiveness, the carbon price should cover major emitting sectors of the economy (e.g., power, upstream on fuels for transportation, and industry). For some sectors upstream price application may be most efficient, such as a price on emissions from oil refineries. Emissions from lands and forests are best handled outside of a carbon pricing program, through other complementary policies, since there are specific and complex issues related to additionality, verifiability and permanence of emission reductions in these sectors.
3. **Proactive use of revenues.** The considerable revenues that would be raised as a result of a robust carbon price present an important opportunity to make investments in a just and equitable clean energy transition as well as in climate resilience to ensure benefits to people around the country. The use of these revenues has important implications for distributional fairness and engaging with key stakeholders (including fenceline and frontline communities and fossil fuel dependent communities) is vital. This is **a hugely important policy choice that must be made with the interests of the broader public squarely in mind**. Priorities—such as appropriately offsetting the disproportionate impacts of energy price increases associated with a carbon tax; transition assistance for coal workers and coal-dependent communities; assistance for communities facing climate

impacts, especially frontline low income and minority communities; and investments in climate-resilient low-carbon infrastructure—require dedicated funding which could come from carbon revenues, or would require appropriations from Congress. Additionally, carbon revenues could be invested in low-carbon technologies, infrastructure and R&D.

4. **Advances equity and environmental justice (EJ) considerations.** Putting a price on carbon has an economy-wide effect, and good policy design requires addressing potential equity implications. These equity and EJ concerns include: the regressive impact of potential energy price increases on low-income households; the potential for carbon pricing policies to allow some fossil fuel-fired power plants, refineries, or other commercial and industrial emitters to continue to operate (or even ramp up operation) and emit air and water pollutants in neighborhoods already burdened by pollution; and the economic hardship to workers and communities dependent on fossil fuel industries for livelihoods or for their tax base as we transition away from these resources. Carbon revenues can provide a source of funding for helping to proactively address some of these concerns, alongside other targeted policies, but these should not be viewed as a complete solution to the important concerns raised by EJ advocates. For example:
    - Rebates and energy efficiency measures designed for low income or fixed income households can help ensure they do not pay a disproportionate share of the cost of cutting carbon.
    - EJ communities are often hit hardest by pollution from the fossil energy sector. That pollution can be limited by pairing a carbon pricing policy with investments in local clean energy and efficiency initiatives, tighter controls of local air and water pollutants and toxics, and incentives for retiring coal-fired power plants.
    - Workers and communities affected by the move away from fossil fuels should receive transition assistance through worker training programs, economic diversification initiatives, and funding for pension and medical benefits that may be adversely affected as current business models rapidly become untenable.
    - Since a carbon price does not guarantee emission reductions—of carbon or other co-pollutants—in specific locations such as EJ neighborhoods overburdened by pollution, additional measures will likely be needed to ensure mandatory emissions reductions in EJ communities. Innovations in carbon policy design that include a cost for co-pollutants could also provide a path forward.
5. **Transitional protection for energy-intensive trade-exposed industries**. Border tax adjustments and/or the targeted use of carbon revenues to provide tax credits to EITE industries can help limit international or state-by-state competitiveness concerns (as well as help address leakage concerns). These types of incentives should be structured in a targeted, bounded way to ensure a transition to low-carbon production methods and products over time, and to avoid windfall giveaways to fossil-fuel industries.
6. **Flexible and durable**. A long-term carbon pricing program must be designed with the flexibility to be updated as new science or new technologies or other relevant considerations become available. A key design feature for a carbon tax should be an environmental integrity mechanism that would allow for the tax to be updated if sufficient emission reductions were not being achieved.

7. **Considerate of international interactions**. Transitional support for EITE, through credits and/or border tax adjustments, can assist in avoiding emissions leakage internationally. Carbon pricing design should be further mindful of opportunities to leverage international cooperation where program linkage would guarantee mutual benefits. The United States should provide funds for international emissions reductions efforts, particularly in developing countries; these could be paid in full or in part by a subset of carbon pricing program revenues.
8. **Considerate of existing state and regional programs**. A national carbon pricing program will help ensure that all states are on the path to net zero emissions by 2050. However, this should be considered a floor, and policy design should aim to allow for, where practical, the continuation of more ambitious existing state and regional policies in parallel with a national program.

Need for complementary policies

However, carbon pricing is not sufficient on its own to achieve the transformational change demanded by the ambitious carbon reduction targets appropriately identified by this Committee. Carbon pricing addresses a specific market failure (the failure to consider climate impacts) related to our reliance on fossil fuels, but not all relevant market failures that impede a low-carbon transition (such as: other barriers to transitioning away from fossil fuels and the public health harms from other co-pollutants produced when fossil fuels are produced and burned). A carbon price on its own will not be able to address the full gamut of what will be needed to get to net zero by 2050. For example:

- We will also need to scale up investments in R&D and transmission infrastructure, barriers created by high upfront costs of technologies or lack of information which can hold back clean technology, and the public goods nature of infrastructure to support clean energy deployment.
- In the transportation sector, a carbon price will only raise gasoline prices by pennies on the gallon which will not be enough to create incentives for cleaner fuels or more efficient vehicles or the infrastructure required to electrify transportation.
- We will need additional policies to safeguard and enhance soil and forest carbon sinks.
- We will also need policies and regulations to address emissions from non-CO2 GHGs such as methane.

As policymakers work to develop approaches that will deliver the level of carbon pollution reductions desired, they must exercise care to ensure that the entirety of the hurdles facing economy-wide decarbonization are overcome—or we risk falling short.

UCS's long experience working on clean energy issues clearly highlights the critical importance of policies like renewable electricity standards, renewable fuels standards, power plant carbon standards, fuel economy and emission standards for vehicles, energy efficiency standards, incentives for research and development, investments in clean energy infrastructure, and other policies to help drive a clean energy transition. A carbon price can work in a complementary way with these policies but should not be seen as a substitute.

Such a suite of policies should be designed and evaluated comprehensively, as the various approaches are specifically intended to cover gaps while limiting redundancies. However, the pursuit of efficiency should not come at the sacrifice of core programmatic priorities, including equity and the development of a solid economic foundation upon which future generations can build.

Notes of caution

Within the criteria named above, there is room for a robust bipartisan conversation about the specific design elements of a carbon price. However, a carbon pricing policy must not be accompanied by:

1. **Regulatory rollbacks that harm public health**. The EPA's authority to regulate global warming emissions is a critical public health safeguard provided by Congress under the Clean Air Act and repeatedly upheld in the courts. It must not be negotiated away.
2. **Any form of legal indemnification for fossil fuel companies** that takes away the legal rights of those affected by climate impacts caused by fossil fuel companies' products. Some of these companies have publicly said they support a carbon price—yet have continued to undermine actual legislative efforts to secure one at the state and federal levels. We urge them to come to the table in good faith and live up to their public pronouncements.