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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, D.C.

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

Members present: Representatives Tonko, Clarke, Peters, Barragan, McEachin, Blunt Rochester, Soto, DeGette, Matsui, McNerney, Ruiz, Dingell, Pallone (ex officio), Shimkus, 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 Directory, 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 & Environment & Climate Change; Brandon Mooney, Minority Deputy Chief Counsel, Energy; Brannon Rains, Minority Staff Assistant;

and Peter Spencer, Minority Senior Professional Staff Member, Environment & 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 minute after Chairman Pallone has spoken. I recognize myself for four minutes for the purpose of an opening statement.

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 American'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 and 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.

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.

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 carbonization 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 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 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.

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.

Mr. Pallone?

The Chairman. Thank you, Chairman Tonko.

One of this committee's top priorities is combating climate

change. Yesterday, I joined Chairman 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.

U.S. 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.

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.

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 stands 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.

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

STATEMENT OF MR. HAUSKER

Mr. 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 the 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 concentration 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 or 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 modelists -- 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 it 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 Mr. Hausker follows:]

**********INSERT 1**********

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 2 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 geological 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 demonstrated 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:]

**********INSERT 2**********

633 Mr. Tonko. Thank you, Ms. Angielski.

634 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 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 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:]

**********INSERT 3**********

Mr. Tonko. Mr. Cohen, thank you.

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

STATEMENT OF MS. CLEETUS

Ms. 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 6 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 in 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, and 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 Ms. Cleetus follows:]

**********INSERT 4**********

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 is 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 disruptive.

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 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.

Dr. 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, okay, 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?

Ms. 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?

Ms. 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. Okay. 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 because --

But this is a million tons of oil equivalency. So this is IEA -- International Energy Agency -- world energy outlook, and so -- until 2040 and it shows U.S. would look 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 is 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 chairman -- the Chair now recognizes Mr. Pallone, full committee chairman, for five minutes to ask questions.

The Chairman. 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 try to legislate 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 there is a -- it is much less risky to invest in multiple technologies that can get us there as long as we manage all of the environmental issues.

There are not only just CO2 but there is 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.

The Chairman. 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 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.

The Chairman. 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?

Ms. 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.

The Chairman. 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 will do that.

The Chairman. 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 a coal 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 ag 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 ag sector. Expanding that would be a really big step throughout the ag 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 -- let me ask Dr. -- is it 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 samples 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 and 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 gentlelady 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 and 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 a 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?

Ms. 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 two-fers. 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. 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?

Ms. 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.

Ms. Cleetus. -- to how we deploy nuclear power.

Mr. Walden. Right. Of course. 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. Okay.

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. -- for the vehicle fleet.

Dr. Cleetus?

Ms. 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 is other things we can do to be smart.

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.

Ms. 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?

Ms. 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 aren't 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 website 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. Mm-hmm. Okay.

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. Barragan of California for five minutes to ask questions.

Ms. Barragan. 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 L.A. and that is a good example of what can be done. The Port of L.A. 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 in transportation.

Ms. Barragan. Great. Thank you.

Dr. Cleetus, maybe you can weigh in on the rollback of the administration's clean fuel standards.

Ms. 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. Barragan. 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. Barragan. Thank you. I yield back.

Ms. Clarke. The gentlelady 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 absorbent 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 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. Okay. 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. Okay. All right. Great.

Ms. Angielski. -- 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. Yeah.

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 gentlelady 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?

Ms. 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 opportunity here of building 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 --

Ms. 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 done 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. Okay. 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. Okay. Fine. Thank you, and I yield back.

Ms. Clarke. The gentlelady 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 Chairman, 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-mileage 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 needed 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 -- 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?

Ms. 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.

Okay. Dr. Cleetus?

Ms. 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, the 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 2 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, Chairman, 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 52 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. Is he right?

Ms. Angielski. With respect to renewables -- is that what you're referring to?

Mr. McKinley. Yes. 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 for 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 gentlelady 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. Okay. How about you, Ms. Cleetus?

Ms. Cleetus. Absolutely yes.

Ms. DeGette. Okay. And how about you, Mr. Cohen?

Mr. Cohen. Yes.

Ms. DeGette. And how about you, Ms. Angielski?

Ms. Angielski. Yes.

Ms. DeGette. Okay. So all of you agree that we could -- we have those technologies available and they are becoming more and more -- more and more cost effective, I think.

I wanted to ask about -- but 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. I have been -- 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 reduce the -- improve the technology and reduce costs. Instead of putting a time frame of 10 years on it might not be practical.

Ms. DeGette. Okay. 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?

Ms. Cleetus. Ten years will be deeply challenging. But 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 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 -- 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.

I don't -- I don't know -- is my time up?

Ms. Clarke. [Presiding.] Your time has expired.

Ms. DeGette. Okay. 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 gentlelady 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 2 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 come 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.

Ms. 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 rule 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 is actual 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 gentlelady from Michigan, Mrs. Dingell, for five minutes to ask questions.

Mrs. Dingell. Thank you, Madam Chair, 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.

Ms. Cleetus. We can and we must.

Mrs. Dingell. That is great. Okay.

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?

Ms. Cleetus. It's urgent because of the climate impacts we are already feeling at 1 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.

Ms. 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 gentlelady 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 definitely need climate justice, and we cannot have one without the other.

Dr. Cleetus -- did I pronounce that correctly?

Ms. Cleetus. Yes.

Mr. McEachin. Okay. 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?

Ms. 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?

Ms. 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?

Ms. 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 out 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.

[The information follows:]

**********COMMITTEE INSERT**********

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.]