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OPPORTUNITIES TO ADVANCE RENEWABLE ENERGY AND ENERGY EFFICIENCY EFFORTS IN THE UNITED STATES

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

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OPPORTUNITIES TO ADVANCE RENEWABLE ENERGY AND ENERGY EFFICIENCY EFFORTS IN THE UNITED STATES

TUESDAY, MAY 21, 2019

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:31 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. We are coming to order as we begin our hearing to examine opportunities to advance renewable energy and energy efficiency efforts here in this country.

I want to start by acknowledging, really, the very significant progress that we have seen in renewable energy in recent years. We have seen the costs of many technologies, whether it is wind, whether it is solar, or something else, decline considerably. Many renewables are now cost competitive without subsidies in certain parts of the country, and that is leading to greater investment. In 2018, U.S. corporations broke previous records by signing contracts for 8.6 gigawatts of wind and solar production.

We have also made great progress on energy efficiency. This is also another good story and one that, unfortunately, is not told near often enough. According to the American Council for an Energy Efficient Economy, energy efficiency has helped reduce energy use by about 50 percent relative to what it would have been had 1980 patterns continued. These reductions are saving Americans. They are saving them approximately $2,500 per year. That makes a difference for our families.

We are making progress, but I think we know that we have plenty of areas where we can continue to improve and increase efficiency.

Some of the most impressive work, and I am going to totally brag on my State here and the innovation and the pioneering that we are seeing coming out of the State, and particularly at the Cold Climate Housing Research Center (Center). For example, the Center is designing and building homes that use 80 percent, 80 percent, less energy than comparable homes that are being built without their assistance. So think about what that means in a cold place, oftentimes pretty dark, to recognize those kinds of energy effi-

ciencies. And then, when you compound that with the extraordinarily high cost of heating and just power generation in the State of Alaska, we are really making a difference to families and communities.

I am pleased to be able to welcome back the Center's Chief Program Officer, Mr. Bruno Grunau. Bruno is going to tell us more about the good work they are doing in the Arctic and rural Alaska.

We are also joined by Mr. Daniel Simmons, who is the Assistant Secretary of Energy (DOE) for the Office of Energy Efficiency and Renewable Energy. It is good to have you back before the Committee.

Dr. Martin Keller is the Director of the National Renewable Energy Lab (NREL). We love having our lab directors here and we appreciate, very much, the fact that you were up in Fairbanks for National Lab Day.

Mr. Dan Conant is the Founder and President of Solar Holler. We welcome you.

And Dr. Jason Hartke is the President of the Alliance to Save Energy, an organization that many of us are familiar with.

Thank you all for being here today ready to talk about the important work that you are doing as it relates to increasing efficiency and deploying cleaner technologies.

I am going to provide Committee members with some of the little highlights that make a difference in, again, a State like ours, where our energy costs are so high.

The community of Yakutat in southeast Alaska, 600 people—I think that is a little bit low—a fishing community with no access by road. In 2013 they decided, we have to get control of our costs, because the cost of food in the grocery store was so high because of what it cost them to just keep the lights on at the store and keep the freezer frozen. So they pieced together some federal and state funding. They invested over $600,000 in efficiency upgrades at the local school, at the courthouse and city office. At the elementary school alone, they invested nearly $200,000 to upgrade all of their lighting to LED. And what they are looking at in savings for that little community is about $70,000 a year. That buys them another teacher. That buys them another teacher and an aide, so in that community it is a huge difference.

I also tell the story very often of a beautiful little fishing community called Pelican in southeastern Alaska. Again, pretty small, and there used to be about 100 year-round residents there. But what was happening in Pelican is even though it was a fishing community, the fishermen were just bypassing Pelican because the ice that they would take to keep their fish cool and fresh, the ice cost them too much money, because their power generation was by diesel powered generation and so you have to put the diesel in the boat, get it down there, and you can't even afford to have ice. Well if you don't have ice, you don't have a community. What they then did, small hydropower from Pelican Creek that had made power possible since the 1940s, they looked to address the reality of that small hydro. They invested in a new penstock, new turbines, modern powerhouse. But that then allowed one local family to start a commercial fish buying and processing business five years ago with five employees. This summer, that little processing company has 24

employees. Keep in mind this is a community of 100 so a quarter of the people there are now working there. They have signed a 25-year lease on an old crab plant with plans to expand and grow further. They anticipate shipping out $1 million worth of fish this summer. And all of that is made possible because they had clean, renewable hydropower, and the continued investment in making that resource more abundant and more affordable.

So when we talk about the small, incremental innovation, and again, small hydro, many would say it is not that innovative, but it can transform communities. It can make them sustainable. It can allow people to live and work where they want to.

Those are just a couple stories from my home state. I would venture to say that in every one of yours you have small examples where you are putting families to work, you are allowing a community to be more sustainable.

Our challenge here is to ensure that the costs of new technologies continue to decline and to make sure that upfront costs don't stall out or need or lack that beneficial investment.

We have great experts here today. I am looking forward to hearing your thoughts on what we can be doing to move to that next level.

I will turn to my colleague, Senator Manchin, but I am looking forward to a very interesting hearing this morning.

STATEMENT OF HON. JOE MANCHIN III,
U.S. SENATOR FROM WEST VIRGINIA

Senator MANCHIN. Chair Murkowski, I want to thank you for holding this hearing today and all of you for being here to help us have a better understanding of how we can help.

Energy efficiency is low-hanging fruit. We all know that, and renewable energy is something that we all strive to maximize in every effort and every area that we live.

I would like to welcome our witnesses, and I want to thank all of you for discussing how these technologies can help us address some of the greatest challenges like climate change and energy cost.

I would like to give a special welcome to Dan Conant, a native West Virginian whose company is Solar Holler. I think he gave it away where he was from when he put the holler in there. He is an excellent example of the work ethic and pragmatism that West Virginians are applying to the climate problem.

We need more examples of this in our State and across the country whether we are talking about efficiency, renewables, energy storage or other climate solutions. It is also critical that we work to remove the barriers small energy companies like Solar Holler face as they seek to build competitive businesses. Together, I hope we identify how to overcome these barriers and others so that new businesses can thrive, workers can find jobs in these growing fields and we can put to use all the tools available to solve climate change.

I firmly believe that we can grow the U.S. economy while simultaneously reducing our greenhouse gas emissions if we invest in commonsense solutions. We need policies that promote adoption of cost-efficient solutions that already exist in all scales, whether that

is a wind farm or an LED light bulb, and our policies should ensure a path toward commercialization into the markets.

I am glad that we have Assistant Secretary Dan Simmons here today to tell us about how we can bring down the cost of these technologies. According to the Department of Energy, for every $1 invested in the Office of Energy Efficiency and Renewable Energy, federal taxpayers have seen a return of $20. That's 20 to 1. Low-cost energy is the engine that drives our economy and gives us our competitive edge, but as states like West Virginia and Alaska face the growing threat of climate change, we also must ensure our energy is ultimately carbon-free.

On the home front, as of the last survey in 2015, one in three U.S. households face challenges paying energy bills. These burdens fall disproportionately on low income families, particularly in rural economies like West Virginia.

DOE's responsibility is not just to drive down the cost of energy technologies but also reduce the energy needed to run our businesses and our homes. That is why programs like the Appliance Standards Program and the Weatherization Assistance Program have been so important. They help the pocketbook and, most importantly, the climate.

Last year, the International Energy Agency (IEA) determined that energy efficiency policies alone could potentially achieve more than 40 percent of the emission cuts needed to reach global emission reduction goals. That is why Senator Hoeven and I recently introduced the All-of-the-Above Federal Building Energy Conservation Act with support from a broad stakeholder coalition, including the Alliance to Save Energy. Forty percent of the nation's energy is consumed in buildings, far more than either the transportation or industrial sectors. In fact, the Federal Government is the single largest energy consumer in our country. Our bill would also repeal prohibition on using fossil fuel, something that DOE can never implement. The bill would lower the Federal Government's carbon footprint and energy bills providing long-term savings to taxpayers. This is low-hanging fruit, and it just makes good sense.

In addition to improving the energy efficiency, we will need the deployment of more low-carbon and carbon-free technologies. Renewable energy, including hydropower, currently provides nearly 18 percent of power across the U.S. This number is growing and we need to support that growth and work on necessary solutions, like storage.

At one point, my little state boasted the largest wind farm east of the Mississippi at Mount Storm in Grant County. We want to find ways to welcome more renewable energy to states like West Virginia, including solar, which is so underused in our state, hydropower and wind. Fossil fuels will need to continue to provide critical baseload as we increase penetration of renewables across the country. And so, we are looking at the how to burn them in the cleanest way possible.

The electric grid is undergoing rapid transformation. It is becoming more complex and more flexible and more diverse in terms of energy resources. We need to continue to invest in clean technologies that will keep the grid reliable and that means, also, safe from cybersecurity threats and resilient to extreme weather events.

I look forward to working with Chair Murkowski and members of this Committee on that.

We have a lot to cover today, and I want to thank you again for being here.

Our little State of West Virginia has been blessed with so much energy, and it has helped this country be the great country that it is over all these years. We have had an abundance of coal. We still have probably the finest coking coal in the world. That is in demand all over the world.

We have an ocean of energy under us in natural gas and the wet gas—butane, propane and ethane—that comes from that. We have not developed, and Dan knows that, we have not developed our solar program the way we should, and I think we can rapidly ascent that. Wind is what it is in our state, and it has done quite well. There is a lot going on there.

So we just thank all of you for being here, and we are trying to find an all-of-the-above solution.

Thank you, Madam Chairman.

The CHAIRMAN. Thank you, Senator Manchin.

Senator Gardner, I know that you are very proud of the National Renewable Energy Lab that you host there in Colorado. I don't know if you would want to make an introduction of Dr. Keller.

STATEMENT OF HON. CORY GARDNER,
U.S. SENATOR FROM COLORADO

Senator GARDNER. I would, thank you very much.

Dr. Keller, welcome to the Committee. Thank you, Madam Chair, and I appreciate the opportunity.

Dr. Keller survived—how many inches of snow at your house this morning——

Dr. KELLER. Six or seven.

Senator GARDNER. ——six or seven inches of snow, so come back to Colorado. The ski resorts are going to reopen for the summer. It is going to be a good year.

[Laughter.]

It is my pleasure to introduce Dr. Keller, Director of the National Renewable Energy Laboratory.

I was out at NREL, I guess recently, in the past month, but also last summer when Secretary Perry visited and we saw, firsthand, the growth at NREL under Martin's leadership.

The public-private partnerships NREL has been so successful in developing and the strategic growth at the National Wind Technology Center which is now named the Flat Irons Campus where it has become much more than wind by integrating and testing many different types of energy technologies together for future grids. It truly is amazing, and I hope members of the Committee will have a chance to go out and see the work that they are doing.

Martin, the ninth Director at NREL, joined the lab from Oak Ridge National Laboratory where he served as Associate Laboratory Director for Energy and Environmental Sciences which included programs in bio sciences, energy technology and manufacturing. In 2006, Dr. Keller earned his Doctorate in Microbiology—Summa Cum Laude, I might add (most of us graduated Thank the Laude) from the University of Regensburg in Germany. He was ap-

pointed a Fellow at the American Association for the Advancement of Science in 2013 and multiple boards, advisory panels, including the Science Advisory Board for the Council on Competitiveness.

Dr. Keller, thank you very much for being here today, and welcome to all the witnesses.

The CHAIRMAN. Thank you, Senator.

Let's go ahead and begin with our very esteemed and just good energy panel here this morning.

As I mentioned, we are joined by Daniel Simmons, Assistant Secretary for Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy. Dr. Keller with NREL has been introduced. Mr. Conant has been introduced as the Founder and President of Solar Holler. Jason Hartke, President of the Alliance to Save Energy. And I have had an opportunity to share with you the great work that is done at the Cold Climate Housing Research Center ably led by Mr. Grunau and our friend, Jack Hébert. So, Mr. Grunau, welcome to you as well.

I would ask you to try to keep your comments to about five minutes. Your full statements will be included as part of the record, and then we will have an opportunity for questions and answers once you have completed your opening statememnts.

Mr. Simmons, if you would like to begin the panel, welcome.

STATEMENT OF HON. DANIEL R. SIMMONS, ASSISTANT SECRETARY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. SIMMONS. Thank you.

Madam Chairman Murkowski, Ranking Member Manchin and members of the Committee, thank you for the opportunity to examine the opportunities to advance energy and energy efficient efforts in the United States.

As the Assistant Secretary for the Office of Energy Efficiency and Renewable Energy, EERE, I am responsible for overseeing a broad portfolio of renewable energy, energy efficiency and transportation programs.

We live in an exciting time for energy technologies. In fact, I think we live in the most exciting time for energy technologies in the history of the world with more competitive and affordable sources of energy than ever before. Costs of numerous technologies have declined, have massively declined, in recent years, including solar photovoltaics, onshore wind, electric vehicle batteries and LED lights, just to name a few. We have also seen major improvements in energy efficiency of America's homes, businesses and industries.

Technological innovation has contributed to these dramatic changes. Thanks in part to research and development at the Department of Energy and the national laboratories, the United States leads the world in reducing carbon dioxide emissions since 2005. The electric power sector CO_2 emissions declined 28 percent over this time period to their lowest level since 1987.

Affordable, reliable energy gives America a competitive edge needed to excel in a rapidly changing global economy. But affordable energy does not matter if we can't integrate these sources of energy into the electric grid.

This is why, in addition to energy affordability, EERE is focusing on advancing grid reliability and resilience through energy integration and storage. To execute on these priorities, EERE has issued over $935 million in competitive funding opportunities and selection since December 2008. And also, as of a couple weeks ago, EERE has released all of our funding opportunity announcements for FY19. I'm very proud of the work that all of the staff has done in EERE to execute on those funding opportunity announcements.

One of our major priorities is the Advanced Energy Storage Initiative. As we work to integrate more resources into the nation's evolving energy system, flexibility of both generation and consumption is critical. This is why DOE announced the Advanced Energy Storage Initiative as part of the FY20 budget request. Coordinated across DOE's Applied Energy Offices, this initiative builds on EERE's Beyond Batteries Initiative from FY19. The initiative will tackle the challenges associated with integrating diverse energy sources such as large amounts of variable wind and solar into the grid.

For example, EERE's Water Power Technology Office is working to improve the flexibility of hydropower and pump storage to increase the value of hydropower as a balancing resource to the grid. Hydro is currently the largest source of energy storage on the grid today.

Also, EERE's Fuel Cell Technology Office is conducting research to produce hydrogen with low cost wind and solar, as well as nuclear generation to prevent curtailment of variable renewables and improve the economics of existing baseload resources.

Also, EERE's Building Technology Office is focused on integrated advanced sensors and controls with flexible energy efficient technologies to advance the role that buildings play at providing services to the grid. In fact, the application deadline for the funding opportunity announcement on this building to grid work closes today.

To address the need to integrate diverse energy resources, DOE is seeking $22 million in FY20 to accelerate the conversion of the National Wind Technology Center at the National Renewable Energy to the Flat Irons Campus. This Flat Irons Campus will include an experimental microgrid capable of testing grid integration at a megawatt scale. These advanced capabilities will allow DOE to test a suite of technologies under the Advanced Energy Storage Initiative and leverage the site's future power capacity of 19.9 megawatts with the capabilities of NREL's Energy System Integration facility.

To effectively integrate all of these technologies together, EERE is also focused on emerging challenges of cybersecurity and sustainability. As more EERE technologies are integrated with the electric grid, we are working with the Office of Cybersecurity, Energy Security, and Emergency Response to address emerging cyber risks to design new technologies with cybersecurity as a requirement from the ground up. To that end, EERE is developing a multi-year program plan for cybersecurity per the FY19 Congressional direction.

Increased demand for wind, solar and battery storage is also driving demand for critical minerals and rare earth elements as this Committee heard last week. To ensure sustainable growth for EERE technologies, DOE is focused on determining demand or re-

ducing demand from foreign sources of critical minerals through domestic production and processing, reuse, recycling of earth and use of earth abundant substitutes while addressing end of life considerations.

In conclusion, as the U.S. energy system evolves, so too must DOE's focus. While EERE has historically been focused on driving down the cost of individual technologies, today we are focused more than ever on integrating these technologies together as that is one of the real challenges for the future, that we need to expand on our vision as well to address the value that each source can provide to the grid. EERE is focused on opportunities to improve our flexibility of energy generating resources as well as flexibility of energy consuming resources to advance affordable, reliable and clean energy for all.

Thank you for the opportunity to appear before the Committee today and to discuss the Office of Energy Efficiency and Renewable Energy. I look forward to your questions.

[The prepared statement of Mr. Simmons follows:]

Testimony for the Record

The Honorable Daniel R Simmons

Assistant Secretary
Energy Efficiency and Renewable Energy

FOR A HEARING ON

Renewable Energy and Energy Efficiency in the U.S.

BEFORE THE
UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES

May 21, 2019
Washington, D.C.

Introduction

Chairman Murkowski, Ranking Member Manchin, and members of the Committee, thank you for the opportunity to discuss renewable energy, energy efficiency, and the Department of Energy's efforts to secure America's future through energy independence, scientific innovation, and national security.

As the Assistant Secretary of the Office of Energy Efficiency and Renewable Energy (EERE), I am responsible for overseeing a broad portfolio of renewable energy, energy efficiency, and transportation programs. The technologies in my portfolio advance America's economic growth and energy security while enhancing the reliability and resilience of the U.S. energy system. Knowledge generated by EERE research and development helps drive down the costs of new technologies, supporting the efforts of U.S. industries, businesses, and entrepreneurs in deploying innovative energy technologies. Affordable, reliable energy gives Americans a competitive edge needed to excel in the rapidly changing global energy economy.

We live in the most exciting time for energy technologies in the history of the world, with more competitive and affordable sources of energy than ever before. But affordable energy does not matter if we cannot integrate these new sources of generation into the energy system. This is why in addition to energy affordability, EERE is also focused on enhancing grid reliability and resilience through energy integration and storage.

To advance these priorities, since December 2018 EERE has issued over $935 million in competitive funding opportunities and selections, covering all sectors of the EERE portfolio. Described below, key examples include solar energy and systems integration, cybersecurity for energy-efficient manufacturing, energy-water desalination, bioenergy technologies, and vehicle technologies.

Solar Energy and Systems Integration

On March 26, DOE announced up to $130 million for transformative solar technologies.[1] The funding opportunity targets five research areas: photovoltaics (PV), concentrating solar-thermal power (CSP), soft costs reduction, innovations in manufacturing, and solar systems integration. These projects will make solar energy more affordable, reliable, and secure, while boosting domestic solar manufacturing and ensuring PV is more resilient to cyberattacks.

With more solar being added to our diverse generation portfolio, DOE is expanding its focus into new technologies to reliably integrate variable solar power into the electric grid. On March 25, DOE selected $36 million in Fiscal Year (FY) 2018 funding for research projects to strengthen the integration of solar on the electricity grid, especially at critical infrastructure sites.[2] Called

[1] https://www.energy.gov/articles/department-energy-announces-130-million-early-stage-solar-research-project
[2] https://www.energy.gov/eere/solar/advanced-systems-integration-solar-technologies-assist-situational-awareness-and

the Advanced Systems Integration for Solar Technologies (ASSIST), these projects will enable grid operators to rapidly detect physical and cyber-based abnormalities in the power system and utilize solar generation to recover quickly from power outages, in many cases without human control. The technology developed will be field-demonstrated to see if they could ultimately enhance power system resilience of some of our Nation's critical infrastructure.

Cybersecurity for Energy-Efficient Manufacturing

While Congressional report language called for funding the manufacturing institutes, the FY2020 Budget favors a transition away from the institute model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities. On March 26, DOE announced up to $70 million (subject to appropriations) to establish a new Clean Energy Manufacturing Innovation Institute focused on addressing cyber threats to more energy-efficient manufacturing.[3] The manufacturing and industrial sector consumes about 25% of the Nation's energy. DOE estimates that the adoption of automated controls and sensors provide the potential for up to 15% improved energy efficiency in manufacturing, but these new technologies introduce cybersecurity risks, which can limit their adoption. Addressing these cyber risks can accelerate adoption of energy efficient technologies in manufacturing, helping U.S. manufacturers remain resilient against cyberattacks and globally competitive. The institute is co-managed by EERE and the Office of Cybersecurity, Energy Security, and Emergency Response (CESER).

Energy-Water Desalination Hub

While Congressional report language called for funding the Energy-Water Desalination Hub, the FY2020 Budget favors a transition away from the hub model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities. On December 13, 2018, DOE announced up to $100 million (subject to appropriations) to establish an Energy-Water Desalination Hub.[4] The Hub will address water security issues in the United States, focusing on early-stage research and development for energy-efficient and cost-competitive desalination technologies, including the treatment of non-traditional water sources for multiple end-use applications. The Hub is part of the Water Security Grand Challenge,[5] a White House-initiated, DOE-led framework to advance transformational technology and innovation to meet the need for safe, secure, and affordable water.

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[3] https://www.energy.gov/articles/doe-announces-70-million-cybersecurity-institute-energy-efficient-manufacturing

[4] https://www.energy.gov/articles/department-energy-announces-100-million-energy-water-desalination-hub-provide-secure-and

[5] https://www.energy.gov/articles/doe-launches-water-security-grand-challenge

Biofuel, Bioproducts, and Biopower

On May 3, DOE announced $79 million in funding for bioenergy research and development, including biofuels, bioproducts, and biopower.[6] This funding supports DOE's goal of providing consumers and businesses with a range of domestic energy options that are affordable, reliable, and secure. The FOA topics will advance DOE's objectives to reduce the price of drop-in biofuels, lower the cost of biopower, and enable affordable bioenergy through co-production of high-value bioproducts from biomass or waste resources. Areas of interest include biofuels derived from lignocellulosic feedstocks that are cost-competitive with gasoline or diesel fuels, advanced biotechnology processes capable of increasing energy production from lignocellulosic feedstocks, and co-produced bio-based plastics with improved performance and recyclability of existing plastics.

Advanced Vehicle Technologies

On April 3, DOE announced up to $59 million for new and innovative advanced vehicle technologies research.[7] Topic areas include advanced vehicle batteries and electric drive systems that reduce reliance on critical materials, energy efficient mobility systems, and co-optimized advanced engine and fuel technologies. Separately, on March 1, DOE announced up to $51.5 million for new and innovative research of technologies for trucks, off-road vehicles, and the fuels that power them. The funding opportunity addresses topics in gaseous fuels research, including natural gas, biopower, and hydrogen; heavy-duty freight electrification; hydrogen infrastructure and fuel cell technologies for heavy-duty applications; and energy efficient off-road vehicles. The truck FOA is co-managed by EERE's Vehicle Technologies Office, Fuel Cell Technologies Office, and Bioenergy Technologies Office.

Advanced Energy Storage Initiative

As we work to integrate more resources into the Nation's evolving energy system, flexibility of both generation and consumption is critical. This is why the Department announced the Advanced Energy Storage Initiative (AESI) as part of the FY2020 Budget Request, which includes $105 million for EERE. Coordinated across DOE's applied energy offices, this initiative builds on and expands EERE's Beyond Batteries Initiative from FY2019, and focuses a wide range of technologies to increase the flexibility of energy-generating resources and energy-consuming resources, thereby enhancing the reliability and resilience of energy systems.

The AESI will tackle the challenges associated with integrating diverse energy sources, such as integrating large amounts of variable wind and solar power into the electric grid. For example, EERE's Fuel Cell Technologies Office is focused on producing hydrogen with low-cost wind or nuclear generation to prevent the curtailment of variable renewables in the former and improve the economics of existing baseload resources in the latter. As another example, the Water Power

[6] https://www.energy.gov/articles/doe-announces-79-million-bioenergy-research-and-development
[7] https://www.energy.gov/articles/doe-announces-59-million-accelerate-advanced-vehicle-technologies-research

Technologies Office is working to improve the flexibility of hydropower and pumped storage to increase the value of hydropower as a grid balancing resource.

Technological advances also create new opportunities for flexibility of energy consumption. For example, electric vehicles create challenges and opportunities for the grid of the future. Flexibility in EV charging can create value and help balance the electric grid. The same is also true of buildings, which consume about 74 percent of all electricity used in the U.S.[8] If we can securely improve communication between buildings and the grid, new technologies can allow buildings to shift and shave their demand in response to real-time grid conditions, increasing flexibility on the electric grid.

National Wind Technology Center Expansion

To address the need to integrate diverse energy resources, in the FY2020 Budget Request, the Department is seeking $22 million to accelerate the conversion of the National Wind Technology Center (NWTC) campus into an experimental microgrid (Flatirons Campus) capable of testing grid integration at the megawatt scale. The mission of the current NWTC will expand to support a fully integrated, large-scale experimental research platform, including a Beyond Megawatt Scale Extreme Fast Charging Station to research, integrate, and evaluate electric vehicle fast-charging station impacts on the grid. These investments support research for DOE's Grid Modernization Initiative, which includes reliably integrating variable generation into the electric grid. These expanded capabilities will allow DOE to test a suite of technologies supported under the AESI and leverage the NWTC's future power capacity of 19.9MW with the capabilities of the National Renewable Energy Laboratory (NREL) Energy Systems Integration Facility.

Energy Sustainability and End-of-Life

As demand for energy integration technologies increases, we need to enhance our focus on energy sustainability and end-of-life considerations. Wind, solar, and energy storage are important for the future, but deployment of these technologies is increasing demand for critical minerals and rare earths from foreign and unstable sources. These technologies also present handling, disposal, and recycling issues, which means at the end-of-life they often end up in landfills.

The President's December 2017 Executive Order 13817 "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals" directed Federal agencies, including DOE, to take steps to "ensure secure and reliable supplies of critical minerals" by "increasing activity at all levels of the supply chain, including exploration, mining, concentration, separation, alloying, recycling, and reprocessing."

To ensure sustainable growth of clean energy technologies and address U.S. dependence on foreign sources of critical minerals, DOE is pursuing a focused research and development

[8] https://www.energy.gov/eere/buildings/about-building-technologies-office

program to reduce supply chain risks posed by the limited availability of critical materials. This program is focused on 1) improvements in domestic production, 2) reuse and recycling, and 3) research into substitutes for critical materials.

EERE conducts foundational R&D to reduce our dependence on critical minerals through the Advanced Manufacturing Office (AMO) and Vehicle Technologies Office (VTO). AMO, for instance, conducts research into earth-abundant substitutes for critical minerals. Meanwhile, VTO is focused on reducing cobalt in electric vehicle battery cathodes and developing new battery chemistries that go beyond lithium ion.

Building on that foundational R&D, EERE recently launched a Lithium-Ion Battery Recycling Prize and established an associated Battery Recycling R&D Center. Lithium ion batteries used in a variety of applications (including consumer electronics, defense, energy storage, and transportation) contain a substantial amount of critical materials (e.g. cobalt, lithium) that are both expensive and dependent on foreign sources for production. Currently, lithium-ion batteries are collected and recycled at a rate of less than 5 percent.

Announced in January, the $5.5 million Battery Recycling Prize encourages American entrepreneurs to find innovative solutions for collecting, storing, and transporting discarded lithium-ion batteries for eventual recycling. The goal of the Recycling Prize and R&D Center is to develop technologies to profitably capture 90 percent of all lithium-based battery technologies in the United States.

While DOE conducts substantial research into recycling and substitutes, we are also expanding our focus to address technical challenges associated with domestic production, processing, and refining of critical minerals. Increasing domestic production without developing the domestic processing and manufacturing capabilities will simply move the source of economic and national security risk further down the supply chain and create dependence on foreign sources for these capabilities.

In addition to battery technologies, EERE is also focused on addressing end-of-life considerations with solar PV and wind turbines. As described above, on March 26 EERE's Solar Energy Technologies Office issued a Funding Opportunity Announcement that included a subtopic on "PV System Recycling and End-of-Life Management." To date, research to address the disposal of PV modules has been limited, and there is a lack of public information on how system components coming offline are being handled by owners or waste-management operations. This research area will focus on understanding the scale and composition of the expected PV waste stream, identifying recycling technologies that could be cost-effectively implemented, establishing tools to inform decommissioning and replacement decisions near the end of a PV system's life, and piloting a process for the recycling of PV components integrated within existing waste-management systems.

Conclusion

The challenge of affordable and reliable energy is what makes DOE's work so important. Technological innovation has contributed to dramatic changes in the energy sector over the last decade, including increased production of wind, solar, oil, and natural gas. Thanks in part to research and development that occurred at DOE and the National Laboratories, the U.S. is now the leading producer of oil and natural gas in the world, and we are exporting LNG to 36 countries.

As a result of our changing energy mix, the U.S. leads the world in reducing carbon dioxide emissions, with electric power sector CO2 emissions declining 28 percent since 2005 to their lowest levels since 1987.[9] The U.S. has achieved CO2 reductions while keeping our electricity prices affordable, with retail electricity rates that are almost three times lower than Germany and about twice as affordable as the European Union.[10,11,12]

While other countries' policies have resulted in higher energy prices and increased CO2 emissions, in the U.S. we have proven that through the power of innovation, we can advance affordable, reliable energy and protect the environment at the same time.

Thank you for the opportunity to appear before the Committee today to discuss the Office of Energy Efficiency and Renewable Energy, and I look forward to your questions.

[9] https://www.eia.gov/todayinenergy/detail.php?id=37816
[10] BP Statistical Review of World Energy, June 2018: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-co2-emissions.pdf
[11] EIA Electric Power Monthly, February 2019
https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_03
[12] Eurostat: https://ec.europa.eu/eurostat/data/database

The CHAIRMAN. Thank you so much, Mr. Simmons.
Dr. Keller.

STATEMENT OF DR. MARTIN KELLER, LABORATORY DIRECTOR, NATIONAL RENEWABLE ENERGY LABORATORY

Dr. KELLER. Madam Chair Murkowski, Ranking Member Manchin, members of the Committee, thank you for this opportunity to examine future opportunities to advance renewable energy in the United States.

Senator Gardner, thank you so much for this nice introduction, so I can skip all this now.

[Laughter.]

So, in my view, the subject of today's hearing could not be more timely or more important. Today, electric generation from renewable technologies are no longer alternative solutions but are becoming significant contributors to our power supply.

According to the Energy Information Administration's Short-Term Energy Outlook, wind and solar are expected to be the fastest growing sources of electricity generation for the next two years. While many advances have been made in new energy technology R&D and commercialization, our nation faces challenges including population growth, increased urbanization and the growing global middle class. It will strain our ability to generate affordable, sustainable energy we need with global demand expected to double by 2050.

So how do we meet these challenges reliably, affordably and responsibly? The answer is continued R&D on the most abundant, affordable, efficient and sustainable energy resources and technologies possible while strengthening and modernizing our national grid.

The grid of today was designed for large-scale, centralized power systems, but with an increasing number of distributed energy sources and grid-connected devices come systems operations challenges and cyber vulnerabilities.

NREL researchers are developing security and power management design principles for the future grid, one that can operate autonomously and support high penetrations of wind, solar and other distributed energy resources that operate very differently than conventional technologies.

It is also imperative to look at ways to make our energy system more flexible, responsive and resilient. Microgrids are one way NREL is exploring to increase overall grid resilience by isolating both the impact of threats and the magnitude of recovery efforts. Decades of work at NREL has driven unprecedented advances in solar technologies. And while innovation is happening at a record pace, further research is needed for solar to reach its full potential.

The time is right to accelerate research into materials such as perovskites, that can be used to produce solar cells quickly and inexpensively using proven, high-speed manufacturing techniques. The same focus is needed on concentrating solar power which promises to be cost-competitive with significant amounts of energy storage using new field designs, advanced manufacturing concepts and novel materials.

In wind, we are collaborating with universities, other national laboratories and industry to drive innovations that promise to produce energy at half the cost of current wind generation in the United States. To achieve this goal, we are working to increase the size of turbines at the heights at which they sit to sizable, scientific and engineering challenges that could create the largest rotating machine ever built. Research is also needed into new materials at advanced manufacturing techniques for onsite turbine blade production that will reduce cost, speed, deployment and allow for the harvesting of our best wind resources.

Bio energy continues to represent a significant opportunity for a sustainable, low-carbon energy and fuels. Key to this area is the development of infrastructure, compatible fuel technologies from biomass that enable affordable, low-carbon gasoline, diesel and short-range alternatives which we have been achieving in collaboration with industry partners.

Recently, we signed a $100 million, ten-year agreement with the National Energy Technology Laboratory and Exxon Mobil to research ways to bring biofuels and carbon capture and storage to commercial scale across the transportation, power generation and industrial sectors. Combined efforts like these could expand the U.S. energy portfolio and strategy.

So in conclusion, national labs such as NREL, along with our partners, are engines for America's innovation. These are the institutions that keep our nation in the leadership role on the world's scientific stage. It is therefore crucial for economic and national security that we maintain our leadership in this area by supporting advancing our national lab system. If we do not, it is certain that our nation's competitors will be waiting to step in and take our place.

Thank you so much.

[The prepared statement of Dr. Keller follows:]

Prepared Statement of Dr. Martin Keller
Laboratory Director
National Renewable Energy Laboratory

For the U.S. Senate Energy & Natural Resources Committee
Hearing on "Opportunities to Advance Renewable Energy and Energy Efficiency Efforts in the U.S."

May 21, 2019

Chairman Murkowski, Ranking Member Manchin, members of the Committee, thank you for this opportunity to examine future opportunities to advance renewable energy in the United States.

My name is Martin Keller, and I am the Director of the U.S. Department of Energy's National Renewable Energy Laboratory, or NREL, in Golden, Colorado. My career has included research positions in the private sector and more than a decade within the national laboratory complex. Before coming to NREL in 2015, I was the Associate Lab Director, and led DOE's BioEnergy Science Center, at Oak Ridge National Laboratory in Tennessee. I previously conducted technology development for a San Diego-based start-up company and I hold a Doctorate degree in Microbiology from the University of Regensburg in Germany. My entire career has focused on integrating foundational science into important new applications. This experience has given me a deep understanding of and profound appreciation for the role of federally supported scientific research in maintaining America's leadership in science and innovation. I also recognize, as I know you do too, how inextricably this innovation is tied to U.S. competitiveness.

Since NREL was founded in 1977, we have been pursuing foundational research in solar, wind, biofuels, and other advanced energy technologies as well as exploring innovations in energy efficiency and smart grids. This includes energy efficiencies in buildings and advanced manufacturing, sustainable transportation technologies and fuels, and using data visualizations and high-performance computing and data visualizations to evaluate energy generation, distribution, integration, and usage models.

Thanks to federal research investments, NREL has been able to advance renewable energy technologies into the mainstream on behalf of the Nation. In fact, the American renewable energy landscape is changing rapidly. Today, solar and wind electricity generation technologies are no longer alternative solutions but are becoming significant contributors to the nation's power supply. According to the Energy Information Administration's short-term energy

outlook, wind and solar are expected to be the fastest growing source of electricity generation for at least the next two years.

Solar energy growth rates have averaged 59% annually over the past decade, and in the first quarter of 2018 solar accounted for 55% of all new capacity installed. Wind power is also accelerating and now accounts for 6.5% of total U.S. electricity generation, about the same as large-scale hydro power production.

These rapid advancements in the growth and impact of renewable energy technologies showcase the role that national labs play in using science to help solve our nation's biggest energy challenges. In partnership with U.S. industry, national labs accelerate innovation to market-based solutions that yield energy systems that are the engine of the U.S.' economic growth and prosperity.

Meeting Our Nation's Energy Challenges

While many advances have been made in new energy technology R&D and commercialization, much work remains to be done and opportunities for U.S. scientific and industrial leadership abound. Population and economic growth, increasing urbanization, and rapidly growing energy demand in developing nations are challenges that require innovation if new energy demands are to be met with sustainable, reliable, and affordable supplies.

As global economies continue to evolve, our energy challenges will only multiply. When cities grow, their energy needs increase. With the global expansion of the middle class, the demand for energy soars. As these urbanization trends continue, it is projected we will need twice the energy resources by 2050, presenting formidable challenges and even greater opportunities for innovation leadership.

So how do we meet these new energy challenges reliably and affordably? The answer is continuing to innovate towards the most abundant, affordable, efficient, and sustainable energy resources and technologies possible, while at the same time working to strengthen and modernize our Nation's energy grid.

Strengthening and Modernizing the Grid

The grid that we know today was designed for large, centralized power systems—and before utilities, grid operators, and customers could predict the potential for today's cyber vulnerabilities. As connected, distributed energy technology deployment increases, so does the number of access points for potential cyber threats. With legacy systems that were not designed

to protect against cyber and physical vulnerabilities, our approach to securing the electric grid must change.

Researchers at NREL are looking ahead to develop intrinsic security design principles for the future grid—one that can operate autonomously, with modern grid technologies to support high penetrations of power-electronics based wind, solar, and other distributed energy resources.

With a focus on understanding both human and natural threats to the grid, NREL's power systems engineers and cybersecurity researchers are working with researchers around the country to mitigate threats to today's energy infrastructure and provide a pathway to a more secure and resilient future grid.

Coordinating Large Generation Plants with Autonomous Grids

Households, businesses and utilities are installing new devices such as electric vehicle chargers, rooftop solar, energy storage, and smart appliances onto the grid at a rapidly increasing rate. As the number of grid-connected devices grows, new solutions and capabilities are needed to optimize distribution power management.

The ability to handle large volumes of communications and data will also become a challenge in managing power. In an optimal system, there would be good communications and visibility between the bulk power and distribution systems to keep the overall grid in equilibrium and to optimize asset use. This would create more real-time options for operating decisions that could benefit customer preferences, energy economics, and grid stability.

One solution to this challenge that NREL researchers and other research institutions are exploring is Autonomous Energy Grids—or AEGs. Unlike current systems that rely on centralized grid control, AEG systems could self-organize and control themselves across all parts of the grid using advanced machine learning and simulation. Sections—or "cells"—of AEGs use pervasive communication to continually pursue optimal operating conditions, which continually adjust to changing customer demand, available generation, and pricing.

There's already progress toward commercialization of AEG algorithms. The NREL created mathematical approach to power and optimize AEG has been selected by DOE's I-Corps program for advancement to market and IP Group has picked up AEG as a candidate for their tech-acceleration portfolio. In addition, Siemens and NREL are collaborating on distributed control techniques with support from the DOE Solar Energy Technologies Office.

Deploying Microgrids for Resilience

Beyond capturing and optimizing the use of energy, it is equally imperative to look at ways to make our energy system more responsive, flexible, and resilient. Microgrids are important elements to look at as they have the potential to increase overall grid resiliency by isolating both the impact of threats and the magnitude of recovery efforts. This capability will be critical to the protection of critical infrastructure such as defense facilities, hospitals, and emergency response centers. Continued research and experimentation are needed to develop better microgrid controllers and strategies for managing new energy systems configurations.

The Future of Solar Energy Research

Decades of investment by DOE in solar energy research and development has driven unprecedented advances in performance, massive cost reductions, and ultimately greater commercial adoption of solar technologies. While innovation is happening at a record pace across the entire solar energy ecosystem, further research is needed for solar to reach its full potential. Continuing foundational science—including chemistry, electrochemistry, materials science, semiconductor physics, and computational science—is crucial to driving the next generation of breakthroughs that will make solar an essential part of the energy systems at all scales.

Foundational science underpins the innovation we are achieving in photovoltaics, what we refer to as PV. Not only for the materials needed for the cells, but also for the research behind power electronics, energy storage, and grid integration. This science ranges from enabling new and low-cost solar absorber materials and manufacturing techniques to complex energy systems modeling and new field applications. For example, lightweight PV materials are becoming increasingly important to the U.S. military, which is seeking highly mobile and agile methods of powering computer and communication systems for soldiers on the ground. New uses of solar technology could give drones the ability to operate continuously or enable extended forward military operations with PV-powered microgrids.

Transforming Solar with Perovskites, Concentrating Solar Power

New materials offer the opportunity to accelerate solar innovation and adoption. Perovskites, for example, could become one of our greatest advances in PV materials. In recent years, perovskites have shown promise as a viable PV material with the potential to increase efficiencies and lower manufacturing capital and operating costs when compared to traditional silicon materials, which currently dominate the market.

We have shown that perovskite-based solar cells could be produced quickly and inexpensively using techniques such as roll-to-roll manufacturing. Imagine solar cells rolling off the production line as quickly as a newspaper is spun across a printing press. We are convinced that PV based on these materials would forever transform the U.S. solar industry.

NREL is a world leader in this technology and we are working with major academic groups and startup companies to make power from perovskites commercially viable. The time is right to accelerate perovskite research. We can bring industry, universities, and national labs together to solidify U.S. leadership in this potentially huge new field.

Another area of promise is concentrating solar power, or CSP. By concentrating, storing, and releasing the heat generated by the sun, CSP systems could achieve competitive generation costs with 8-to-15 hours of energy storage. However, the challenge of CSP research is developing a viable thermodynamic power cycle, which requires advanced, high-temperature working fluids and long-term thermal energy storage. In addition, the capital expenditures needed to deploy the solar mirror fields of CSP systems are very high. Cost-effective, next-generation CSP field designs are needed to drive adoption and we are working closely with industry to reduce these costs by using advanced manufacturing concepts and new materials currently being researched.

The Future of Wind Power Research

Federal investments into wind power research and development are responsible for major advances in wind technology and commercial adoption. We are collaborating with universities, national laboratories, and industry with the goal of using foundational research and applied science to drive innovations that produce energy at half the cost of current wind generation in the United States.

We believe there are opportunities to design and engineer wind turbines that are larger and more flexible than current turbines, which will allow access to the additional wind power available at taller turbine heights. Researchers and industry alike project an increase in land-based turbine size into the 200-meter-plus diameter range deployed on towers extending to more than 150 meters high (a total height of greater than 800 feet). These heights are necessary in order to achieve the economies of scale needed for a significant reduction in the cost of wind energy. Putting this scientific and engineering challenge into perspective, it will make next-generation wind turbines the largest rotating machines ever built.

The complexities presented by offshore wind turbines that also continue to grow in size is an area where significant research is needed—including the aerodynamics of wind flow through rotors, hydrodynamic forces of waves and currents on the support structures, advanced materials, and controls. In addition, these machines must be designed to survive extreme weather such as

hurricanes and icing that are prevalent along the East Coast and in the Great Lakes where some of the best wind resources exist.

Large, floating offshore systems located in the Atlantic and Pacific Oceans at water depths of 50 meters or more, present additional challenges. Research is needed to address the motion of the buoyant turbine platforms anchored to the sea floor by mooring cables. With larger turbines and platforms, there is greater need to moderate buoyant motions with advanced control methods, lightweight material designs, and new hydrodynamic platform configurations to ensure reliable operation.

Reducing Costs with On-Site Blade Manufacturing

Turbine blade materials and manufacturing techniques have not advanced significantly since the 1990s and are still based on low-cost composite fibers and durable epoxy resins. Research into advanced materials and adhesives are needed, as is R&D into new manufacturing methods such as 3D printing and onsite manufacturing. For example, one opportunity for blade improvements through materials is the transition to thermoplastic resins. These resins would allow the "welding" of the composite structural elements while enhancing blade recyclability at the end of commercial life.

As turbine blades increase in size—extending up to two football fields long—the greater the costs are of transporting blades from manufacturing sites to wind farms. Much of this cost, and the associated logistics and transportation challenges, can be reduced by using on-site manufacturing methods. Research into creating mobile, on-site manufacturing facilities and techniques is needed to produce strong, lightweight blades in ways that reduce costs and speed field deployments. Success in this area will require advanced materials and processing science.

The Future of Bioenergy Research

Another area in which NREL is pursuing foundational science is the broad spectrum of bioenergy technologies. Our research is advancing biofuels, biochemicals, and biomaterials sourced from lignocellulosic biomass—plant matter abundant across the United States that is typically available as agricultural waste and other residue. Estimates show that by 2030, the United States will have the capacity to produce a billion dry tons of biomass resources annually for energy use, without impacting other vital U.S. farm and forest products. This domestic resource represents a significant opportunity for sustainable, low-carbon energy and fuels.

What does this mean for the average American citizen? A billion dry tons of sustainable biomass has the potential to produce: electricity to power 7 million households; 50 billion gallons of biofuels displacing almost 25% of all transportation fuels; 50 billion pounds of bio-based

chemicals and bio-products, supplying a significant portion of the chemical market; and 450 million tons of carbon dioxide equivalent reductions every year.

Key to this area of research is the development of infrastructure-compatible fuel technologies from biomass that enable affordable, low-carbon gasoline, diesel, and jet-fuel alternatives. Through research on bio-based hydrocarbon fuel technology development—in collaboration with Ensyn, Petrobras, and Chevron—NREL has demonstrated proof of concept for co-utilization of pyrolysis oil in existing refinery operations. The resulting renewable gasoline and diesel has garnered EPA approval as an advanced biofuel.

Using Our Bioenergy Expertise to Solve Other Challenges

The added benefit of conducting foundational science is serendipitously finding ways to solve other crucial challenges. In a logical evolution of our current research in converting biomass into biofuels and bioenergy, we have discovered industrially relevant solutions to help solve challenges associated with the world's plastics pollution problem. For example, NREL scientists have discovered how to transform discarded plastic products into new, high-value materials of better quality and environmental value—referred to as "plastics upcycling"—that could economically incentivize the recycling of waste plastics. The NREL team chemically combined reclaimed polyethylene terephthalate plastic, or PET, with bio-based compounds to produce valuable, fiber-reinforced plastics that can be used in products from snowboards to wind turbines. Not only are the resulting composites worth more than the original PET, the materials are twice as strong and use a more energy efficient and less hazardous process compared to the standard petroleum-based manufacturing processes.

In addition, NREL and an international team recently engineered a natural enzyme to more efficiently break down PET, and we are working now with a large group of collaborators to find even better enzymes that can operate at much higher temperatures in an industrial setting. NREL also leads a consortium of industrial, national lab, and academic partners focused on the development of bio-based acrylonitrile for renewable carbon fiber applications—such as aircraft and vehicles—which have the added transportation-related benefit of light-weighting these vehicles to improve fuel efficiency. We are now engaged with industry to take this exciting technology to a more commercially relevant scale.

Collaborating to Benefit All

NREL's collaborative approach with industry, other national labs, and universities to support commercialization of our research has been demonstrated to be highly impactful, reducing private sector risk in early-stage technologies enabling continued private-sector investments and U.S. competitiveness. That's why the R&D projects I've mentioned are crucial to finding

meaningful solutions to today's energy and environmental challenges. We give U.S. companies a competitive edge in the global energy race by bridging the gap from concept to market and linking R&D with real-world applications.

Underscoring this approach is the $100 million, 10-year agreement we recently signed with the National Energy Technology Laboratory and ExxonMobil. This partnership will support research into ways to bring biofuels and carbon capture and storage to commercial scale across the transportation, power generation, and industrial sectors. It will also foster research collaboration on projects to advance potential scalable technologies that improve energy efficiency, minimize greenhouse gas emissions, and reduce emissions from the production of fossil fuels and petrochemicals. Our combined efforts could expand the U.S. energy portfolio and strategy. Working together with other national labs, we are proving that we can grow our economy while being environmentally responsible and reducing emissions.

In Conclusion

The United States has a unique system for R&D and scientific leadership through the DOE national laboratory system, which many refer to as the "crown jewels" of American scientific discovery. But what does that mean? It means that national labs, like NREL, and their partners are the engines for America's innovation. The scientists and engineers who choose to work at NREL and other national laboratories are among the very best, and they have an abiding determination to shape our energy future into one that is clean, reliable, affordable, and secure. These are the same experts that have enabled NREL to find new pathways to transform and enhance our energy system—everything from keeping our grid secure and the exciting new possibilities of perovskites, to modeling the aerodynamics of wind turbines and creating ways of upcycling plastics.

It's these innovations that keep us in the leadership role on the world's scientific stage. But we should not overestimate the security of our role. Other nations continue to ramp up research in all of the areas I've talked about today. They are looking at our labs systems and thinking they can do something similar or even better. This makes it crucial, for our economic and national security, that we maintain our leadership in this area by supporting and advancing our national lab system. If we do not, it is certain that others will be waiting to step in and take our place.

The CHAIRMAN. Thank you, Dr. Keller.
Mr. Conant, welcome.

STATEMENT OF DAN CONANT, FOUNDER AND CEO, SOLAR HOLLER

Mr. CONANT. Thank you, Senator Murkowski, Senator Manchin, for inviting me, and all the members of the Committee.

I'm honored and humbled today to be able to represent a new industry that's growing rapidly in Appalachia. And today I wanted to share a couple of stories with you, the story of how we re-imagined who solar is for, the story of how we started training the first generation of solar installers in Appalachia and a couple of points about what Congress can do to help further our mission of bringing clean, renewable energy within reach of everybody.

My name is Dan Conant. I'm the Founder and CEO of Solar Holler. We're based in my hometown of Shepherdstown, population 1,500, and we also have operations in Huntington, West Virginia. I also come to you as a former advisor to the U.S. Department of Energy's SunShot Initiative.

For generations, Appalachia has powered American prosperity with coal. And at Solar Holler we are doing everything we can to ensure that we continue powering America for the next 100 years, just this time with their sunshine.

From the moment I moved back to my hometown to start up our company six years ago, we have relentlessly pursued innovative approaches that make solar the most affordable source of energy for all of our neighbors across Appalachia. Due to this dedication and approach, we are a rapidly growing team of incredibly dedicated, talented and passionate folks. In the past year, we've grown from 10 staff to 35, which might not sound like a lot but it is a huge deal in rural West Virginia to have a growing company of 35. Our team models, designs, finances and builds beautiful solar projects that are going to last for generations while helping families, nonprofits and businesses across our region cut their power bills.

Our dedication to making solar the most affordable source of energy for the folks who need it most was shown in our very first project, a groundbreaking community effort with my congregation at the Shepherdstown Presbyterian Church. That project was so cool because of a first-of-its-kind crowdfunding approach where we never asked for a dime from anybody, instead we asked people to let us install a remote control on their electric water heaters.

We had 100 water heaters in our tiny little town. One hundred families and businesses agreed to support the project by letting us aggregate a network of water heaters into a virtual power plant on the PJM grid where turning the water heaters on and off every two seconds with fluctuations of the frequency regulation market. And then we're using the revenues from this power plant to fund a revolving loan fund to support solar on churches and homeless shelters and other amazing community organizations around our state.

The CHAIRMAN. Let me just tell you, that is cool.

Mr. CONANT. Thank you.

The very first project with Shepherdstown Presbyterian would have cost the congregation over $50,000, instead it cost them $1 and we launched it five years ago. Over 25 years, it's going to save

the church over $100,000. That's $100,000 that can go toward the mission of the congregation which is to clothe and care for and feed our neighbors.

We had to get that creative and develop an approach like that because when we attempted to do the first power purchase agreement in West Virginia, we were prevented from doing so by the West Virginia Public Service Commission because it was at odds with our state granted utility monopolies and without those PPAs, the IRS has ruled that solar projects on non-profits are ineligible for the federal investment tax credits. Additionally, the USDA Rural Energy for America program which administers loan guarantees and grants for businesses across rural America, they specifically will not support any non-profit project. So we just had to get creative with what we had to work with.

But word in West Virginia got around fast that this was a really cool project and things were happening. So within a week we actually outstripped the capacity of everybody who knows how to install solar in West Virginia. It took us less than one week to get there.

In 2015 we launched Rewire Appalachia, a workforce development and training program, in partnership with Coalfield Development Corporation. Through this collaboration we've given young folks whose families have been in the mines for generations a hand up into the solar industry. We invest in their Associates Degrees at the local community college. We paid for their electrical journey worker courses. We enrolled them in their NABCEP solar certification training work, and they got to join our full-time crews earning real living wages as we went around deploying projects on non-profits around West Virginia.

At Solar Holler we like to say it takes all kinds to pull a solar project off. Of course, you need the talented electricians and roofers but it also takes designers, engineers, warehouse workers, procurements, project managers. It really takes all kinds to pull these projects off.

And ever since then, we've been building that entire supply chain, that entire industry from scratch, even in the coal fields of West Virginia.

Yeah, so, that's a little bit about our story, and I'd look forward to taking questions from you all later.

[The prepared statement of Mr. Conant follows:]

Testimony of Dan Conant
Founder and CEO — Solar Holler
Before the Committee on Energy and Natural Resources
United States Senate

"Building a Renewable Energy Economy in Coal Country"

I. Introduction

Good morning Chairman Murkowski, Ranking Member Manchin, and all the members of the Committee. I am honored and humbled to have the opportunity to speak with you all today as a representative of the vanguard of a new industry in Appalachia. I want to share today with you three stories—the story of how we re-imagined who solar is for; the story of how we started training the first generation of solar installers in coal country; and the story of what the Congress can do to help further our mission of bringing clean, renewable energy and a jobs within reach of all of our neighbors across Appalachia.

My name is Dan Conant; I am the Founder and CEO of Solar Holler. We are based in Shepherdstown and Huntington, West Virginia. I also come to you as a former advisor to the US Department of Energy's SunShot Initiative, and a veteran of multiple solar startups.

For generations, Appalachia has powered American prosperity with our coal. Solar Holler is ensuring that we will continue to power America in the 21st Century with renewable energy. From the moment I moved back to my hometown to start up our company 6 years ago, we have relentlessly pursued innovative approaches that make solar the most affordable source of energy for all of our neighbors across Appalachia.

Due to this dedication and approach, we are a rapidly growing team incredibly dedicated, talented, and passionate Appalachians. In the past year, we've grown from ten staff to thirty

five. Our team models, designs, finances, and builds beautiful solar projects that will last for two generations—all the while producing free, clean energy. Every project our team designs and builds helps families, non-profits, and businesses across our region cut their power bills, while revitalizing the economy of West Virginia.

Our dedication to making solar the most affordable source of energy for the folks who need it most was shown in our very first project—a groundbreaking community effort with my congregation, Shepherdstown Presbyterian Church. The project won national accolades—including the Interfaith Power & Light National Renewable Role Model award—for a first-of-its-kind crowdfunding approach.

Rather than passing a plate or doing a traditional capital campaign, we crowdsourced water heaters. Members of the congregation (and half the businesses in town), agreed to let us connect an internet-connected remote control to their water heater. We connected one hundred water heaters in a network—a network that we registered as a virtual power plant on the PJM regional grid. By adjusting water heaters second-by-second in tune with fluctuations of the needs of the regional grid, we have been able to incorporate more renewable energy into Appalachia's grid. We also created a new source of funds to support solar projects at churches, homeless shelters, affordable housing, and libraries across our state. That first project with my church would have cost the congregation more than $50,000 at the time. Instead it cost them $1. Over 25 years, that project will save the Church more than $100,000. That's $100,000 that rather than going to a large out of state corporation will go towards the mission and the ministry—feeding, housing, and clothing our neighbors.

We had to get creative and develop this approach because the normal model of using a Power Purchase Agreement in which a solar company sells the power to a non-profit was ruled by the West Virginia Public Service Commission to be at odds with our state-granted utility monopolies. Without those PPAs, the IRS has ruled that solar projects on non-profits are ineligible for the federal investment tax credit. Additionally, the USDA Rural Energy for America Program, which administers loan guarantees and grants to rural and small town solar projects, will not support any non-profit project.

Word in West Virginia gets around fast—especially when we do things first. Within a week so many community organizations wanted solar that we outstripped the capacity of the entire industry and everyone who had ever installed solar in our state. So we set to work building that capacity.

In 2015, we launched Rewire Appalachia—a workforce development and training program in partnership with Coalfield Development Corporation, a non-profit in Wayne County, West Virginia. Through this collaboration, Solar Holler has given young folks whose families have been in the mines for generations a hand up into the solar industry. We invested in their associates degrees at Mount West Community College; we paid for their electrical journeyworker courses; and enrolled them in their NABCEP solar certification training coursework. Apprentices have been able to further their educations, while learning on the job under the close supervision and tutelage of our Master Electricians.

At Solar Holler, we like to say it takes all kinds to pull a solar project off. It of course takes talented, eagle eyed electricians and roofers. But it also takes designers, engineers, warehouse and procurement staff, accountants, project managers, financiers, marketing, and everything else that it takes to support a team as big as ours. With no existing industry in the regions where we work, we've had to build up a new one. We needed to build the supply chains, build the financing tools, and work with local building inspectors who had never seen a solar project before.

Every day we are spreading the economic benefits of new solar and new energy into ancient hollers and ancient homesteads.

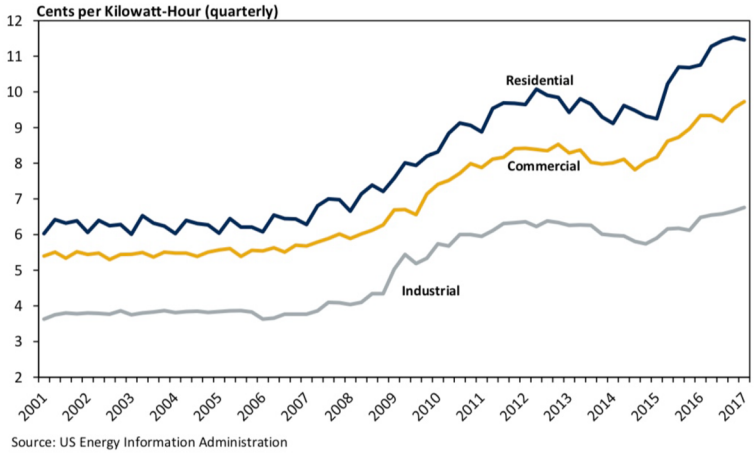
II. Market Demand for Renewables in Appalachia

It may seem counterintuitive that solar could be doing so well in Coal Country. After all, the common perception around the nation is that solar is eating into coal's market share. But

coal jobs have been declining for generations in my state due to automation and the move toward surface mining from underground mining.

Yet every day we work with retired miners, kids of miners, and families who have been sustained by coal for generations. When you ask a retired miner why they're going solar when they spent a lifetime in the mines, the answer is invariably the same: to save money and free themselves from the utility. It's no wonder. From 2008-2017, utility rates have dramatically increased across our state—increasing at the fastest rate of any state in the nation. During that period, rates increased at an average of 6.1% per year, compared to a national average increase of 1.4% annually. (McKinsey and Company, 2017). In just a decade, utilities have nearly doubled their rates—going from 6 cents per kWh to 11.5 cents per kWh.

That doubling is hard on our neighbors. We have the second lowest median income in the nation. Median income is 28% below national average. So when utility rates rise, it hurts. At 12,000 kWh per year, the average utility bill eats up more than 4% of the median take home income.



Source: US Energy Information Administration

III. Solar Economics in Appalachia

While monopoly utilities continue to increase their rates year after year for West Virginians, solar has gotten cheaper. And cheaper. And cheaper. Since 2010, the price per Watt of a solar panel has decreased by over 80%. Utility scale solar farms have declined from $4.50/Watt to just $1.03/Watt. Nationwide, residential scale solar prices have declined by 24% just in the last 5 years. Across Appalachia, homeowners and businesses alike are looking to these declining prices as a source of relief from their ever-increasing utility rates.

The single biggest incentive to assist homeowners and businesses in going solar is the federal investment tax credit. Expanded in 2005, and renewed in 2015, this tax credit enables system owners to reduce their system cost by 30%. While coastal states like Massachusetts and California have other state based incentives, in West Virginia and Kentucky, that is our only source of support. So we've needed to make solar work economically on its own.

IV. Policies to Make Solar Affordable for All of our Neighbors

While our team is amazing and I'm proud of the work we've done to build this industry, there are still challenges that have been put in place by state and federal policy—challenges that could be addressed by the members of this Committee. As I mentioned at the start, our mission is to bring solar within reach of everyone—not just the well-to-do. That's why we work with congregations and shelters and affordable housing. That's why we work with retirees and folks across the coalfields that the rest of the country has forgotten.

But the solar investment tax credit—the largest incentive for solar, and the only one for us here in West Virginia—only helps if you're paying taxes in the first place. That's no problem if you're a Google or Amazon; and it's no problem if you're making six figures. But for the retirees that call us every day worried about how they're going to afford a $400 electric bill on their social security income, or a non-profit that doesn't pay taxes at all, a solar tax credit is of no use.

So a retiree on a fixed income is expected to pay more for their solar project than a doctor. A homeless shelter is expected to pay more for their project than a successful business.

Even families that have stable incomes in our state aren't able to fully benefit from the tax credit on account of their incomes. For a family making the median household income in West Virginia—$43,469 in 2017—the average federal income tax bill is under $2,000. Yet the tax credit on an average solar system size would be more than $6,000. As a result, the normal homeowner in West Virginia is forced to extend their credits years into the future, delaying their payback compared to their wealthier neighbors or folks in other states.

Congress could help level the playing field for all Americans and organizations wanting to go solar in three principal ways:

1. Make the Investment Tax Credit refundable—to ensure that low to moderate income families aren't left out and expected to pay more than their neighbors for solar.

2. Expanding eligibility for the investment tax credit to include tax exempt entities. This could be modeled on the successful Section 1603 Treasury Grant program that was instituted in response to the collapse of the tax equity markets following the 2008 Financial Crisis. It could also be achieved by directing the IRS to reconsider its restrictions on eligibility that discriminate against projects in certain states.

3. Expand eligibility for USDA Rural Development programs (particularly the Rural Energy for America Program) to support low-income and non-profit solar projects. All solar projects on a school or a library in a rural areas help re-invest dollars in the local economy and build new industries just as much as a project on a small business.

V. Conclusion

Chairman Murkowski, Ranking Member Manchin, and all the members of this Committee—thank you for inviting me to share these thoughts with you today. I am thrilled

every day to be doing my part to build a 21st Century industry in my home state. We have demonstrated that there is demand for solar, even in Coal Country. Yet there are still challenges that keep many of our neighbors and community organizations from enjoying the benefits of lower bills, and control over their power source. I look forward to working with this committee to bring solar within reach of all Americans.

Thank you,

Dan Conant
Founder & CEO
Solar Holler

The CHAIRMAN. Thank you, Mr. Conant, that is an impressive story and one very important for this Committee to hear. We appreciate the innovation.

Dr. Hartke, welcome.

STATEMENT OF DR. JASON HARTKE, PRESIDENT, ALLIANCE TO SAVE ENERGY

Dr. HARTKE. Thank you, Chairman Murkowski, Ranking Member Manchin, members of the Committee. Thank you for the opportunity to testify today.

We greatly appreciate the Committee's bipartisan leadership and strong focus on energy efficiency as a leading solution to our nation's energy and environmental challenges.

The Alliance, as many of you know, has a long history in energy policy. We've been part of every major bipartisan energy efficiency bill enacted into law since our founding in 1977, and we're honored to have an honorary board made up of 14 Members of Congress, several of whom serve on this Committee, including the Chairwoman, Senator Alexander and Senator Wyden.

On a personal note, I just wanted to mention that my grandfather, Vance Hartke, also had the high honor of serving in the Senate, representing the great State of Indiana for 18 years. I just have a deep appreciation and respect for this legislative body and the work you do in your public service.

As President of the Alliance, I'm humbled by the enormous opportunity in front of us to transform our energy sector through energy efficiency and I'm proud of the progress we've made.

Energy efficiency is the absolute workhorse of clean energy. No solution is more potent, more compelling or more multifaceted. In fact, if it weren't for our efficiency gains over the last 40 years, the United States would be using 60 percent more energy right now—60 percent. Think about how much money your constituents are saving as a result of those gains and think about the economic growth and the new jobs that have been created in communities in every corner of the country.

Today, the energy efficiency has grown dramatically accounting for 2.3 million jobs and making up nearly 70 percent of all clean energy jobs. Nearly half a million of these jobs can be found in the states represented by the members of this Committee alone.

And we know we would not be here, where we are today, without the many key federal energy programs and policies, policies that you guys pioneered. But I'm here to tell you the opportunities ahead are even greater than our past accomplishments.

This is particularly notable in the context of climate change. Energy efficiency is the fastest, cheapest and largest tool we have for reducing emissions. According to IEA, as Senator Manchin mentioned, energy efficiency will need to be more than 40 percent of the solution to meet the goals of the Paris Accord. Put another way, it's virtually impossible to achieve even modest carbon reduction goals without robust gains in energy efficiency.

The good news is that energy efficiency policy solutions double as powerful economic policy. With efficiency we can tackle climate change while simultaneously strengthening the economy. And there

are many actions that we would advocate that this Committee take to seize this opportunity.

Most immediately, we have to protect the policies we have in place today like minimum efficiency standards, the Weatherization Assistance Program and critical R&D investments that drive efficiency throughout the economy. I'm convinced that EERE's leadership and professional staff have the expertise and the ability to do their job as Congress intended, but this Committee can play an important role in making sure their work is done on time, in compliance with the law and absent political interference.

Perhaps the most obvious examples of this need for oversight concerns the 16 energy conservation standards that have missed statutory deadlines and the ill-advised proposal to roll back light bulb standards set to take effect in January. This Committee should exercise its oversight responsibility to help get these overdue standards back on track.

We would also encourage the Committee to take up and pass bipartisan legislation to advance opportunities in energy efficiency across sectors. I've highlighted several specific bipartisan bills in my written testimony that would deliver savings and help lower emissions: the Portman-Shaheen Energy Efficiency bill which is undergoing updates right now and is likely to be introduced very soon; the All-of-the-Above Federal Building Energy Conservation Act which Senator Hoeven and Senator Manchin have sponsored; and the Weatherization Enhancement and Local Energy Efficiency Investment and Accountability Act introduced by Alliance Honorary Advisors, Senator Coons and Senator Collins.

Some of these bills could also easily be included as part of an infrastructure package because infrastructure includes our utility grid. It includes buildings. It includes water and wastewater facilities, transit hubs, public buildings and many other structures. Being smart and forward thinking about infrastructure presents the opportunity to get it right, now, and then save consumers and taxpayers decades in energy costs.

To close, I'd say again, that now is the time to double down on energy efficiency. It is a veritable energy bonanza, as my friend, Amory Lovins, from the great State of Colorado likes to say. But we're not moving fast enough, largely because we don't always see efficiency.

Senator Murkowski, I think you mentioned part of that underestimating energy efficiency. But at a fearless pace, technology is unlocking new and even greater potential through smart meters, smart buildings, integrated design and connected devices. So while efficiency may be hard to see, the opportunity is clear.

The Alliance looks forward to working with you to ensure we realize the full potential of energy efficiency, America's greatest energy resource.

Thank you again for inviting me to testify. I'm happy to take any questions.

[The prepared statement of Dr. Hartke follows:]

Testimony of Jason Hartke, Ph.D.
President
Alliance to Save Energy

U.S. Senate Committee on Energy and Natural Resources
"Hearing to Examine Renewable Energy and Energy Efficiency Efforts in the U.S."
May 21, 2019

Thank you for the opportunity to testify today about the opportunities before us to advance energy efficiency and improve U.S. energy productivity. We appreciate the committee's bipartisan leadership and consistent focus in recent years on energy efficiency as a leading solution to our nation's energy and environmental challenges. We look forward to continuing to work with you in the 116th Congress.

The Alliance to Save Energy is a non-profit, bipartisan coalition of business, government, environmental, and consumer-interest leaders that advocates for enhanced U.S. energy productivity to achieve economic growth; a cleaner environment; and greater energy security, affordability, and reliability. The Alliance enjoys the participation of nearly 130 businesses and organizations that collectively represent at least $615 billion in market capital. The Alliance was founded in 1977 by Sens. Charles Percy (R-Ill.) and Hubert Humphrey (D-Minn.), and today has 14 members of Congress serving on an Honorary Board of Advisers. We are honored that several of those honorary advisers serve on this committee, including Chairwoman Murkowski, Sen. Alexander and Sen. Wyden. Thank you, again, for your leadership.

I want to start with some context. We all know about the oil embargo and fuel shortages of the 1970s – a crisis from which the Alliance was born. That's when the United States – realizing the dire energy and economic security dangers stemming from our overwhelming oil dependence – got serious about using our resources wisely, about making energy efficiency a centerpiece of our energy policy. And, of course, when we get serious about doing something, the U.S. usually succeeds.

That's exactly what we've done with efficiency. Today, the United States would be using 60 percent more energy than we are right now if we hadn't achieved the efficiency gains of the last 40 years. We're doing more with less. In fact, our energy productivity has doubled since 1980, so we're generating more than twice as much gross domestic product (GDP) for each unit of energy we consume now compared to then.[1] Think about how much money your constituents are saving as a result of those gains. Think about how many new jobs have been created in communities in every part of the country. Think about all the unnecessary carbon emissions and other pollution we've avoided. Think about how much more productive and competitive our manufacturers and other businesses are. Energy efficiency is a foundational piece of our energy and environmental puzzle, and it enables many of the exciting new technologies we're talking about today such as storage and renewables.

[1] In 1980, the U.S. consumed 78 quads (quadrillion British thermal units (BTUs)) while GDP was $6.8 trillion, which produces an energy productivity ratio of 87.2. This compares to energy productivity of 186.8 in 2018 (i.e., 101.2 quads and GDP of $18.9 trillion). Energy consumption data is from the Energy Information Administration. GDP (real dollars, 2012) is provided by the Bureau of Economic Analysis.

While technology and innovation certainly have played a significant role in our efficiency gains, we can't understate the role that policy has played. Most of the time these policies have been passed by Congress with strong bipartisan support and enacted by Republican presidents.

Consumers and business save billions every year because we have minimum efficiency standards for appliances and equipment. Our buildings are more energy-efficient and resilient because of regular updates to model building energy codes. States and local governments are able to deliver direct savings and other benefits to homeowners in need because of the Weatherization Assistance Program. Thousands of buildings and manufacturing facilities are saving billions of dollars in energy and water costs thanks to the Better Buildings partnership program. We've reduced the energy intensity of federal government operations by 49 percent since 1975 thanks to leadership of the Federal Energy Management Program. We have world-class federal research and development (R&D) activities underway at the most sophisticated laboratories in the world - facilities that Energy Secretary Perry calls the "crown jewels" of his department. I could go on.

There is no question we wouldn't be where we are today without those policies and programs, not even close. And yet, there is so much more we can do. That's what I want to focus on today – that despite our gains, energy efficiency remains our greatest energy resource, and the opportunities ahead are even greater than our past accomplishments. It is a huge opportunity - just as much an economic opportunity as it is an environmental one.

Many people think of energy efficiency as *turning off the lights*, and they're probably surprised to learn that this diverse and growing industry is actually one of the largest employment sectors across the entire energy field, and by far the largest employer among clean energy industries. According to Environmental Entrepreneurs' Clean Jobs America report released in March, we have 3.3 million clean energy jobs across the country, from energy storage to wind and solar to clean vehicle manufacturing.[2] Energy efficiency doesn't just lead the pack, it accounts for nearly 70 percent of all clean energy jobs, coming in at more than 2.3 million jobs. These are good-paying, stable jobs that are spread across the country. In fact, six in 10 of our efficiency jobs are in construction. The states represented by members of this committee account for nearly half a million of these energy efficiency jobs.[3]

Senator	State	Jobs	Senator	State	Jobs
Lisa Murkowski *Chairwoman*	Alaska	4,617	Joe Manchin III *Ranking Member*	W. Va.	6,844
John Barrasso	Wyo.	7,528	Ron Wyden	Ore.	42,547
James E. Risch	Idaho	8,748	Maria Cantwell	Wash.	63,877
Mike Lee	Utah	31,798	Bernie Sanders	Vt.	11,035
Steve Daines	Mont.	8,673	Debbie Stabenow	Mich.	85,061
Bill Cassidy	La.	22,152	Martin Heinrich	N.M.	5,636
Cory Gardner	Colo.	34,342	Mazie K. Hirono	Hawaii	5,850

[2] E2 (Environmental Entrepreneurs), "Clean Jobs America 2019," March 2019, https://www.e2.org/reports/clean-jobs-america-2019/. Last accessed May 17, 2019.

[3] National Association of State Energy Officials (NASEO) and Energy Futures Initiative (EFI), "Energy Employment By State – 2019," March 2019, https://www.usenergyjobs.org. Last accessed May 17, 2019.

Cindy Hyde-Smith	Miss.	15,403	Angus S. King, Jr.	Maine	8,647
Martha McSally	Ariz.	43,418	Catherine Cortez-Masto	Nev.	11,155
Lamar Alexander	Tenn.	53,006			
John Hoeven	N.D.	5,425			
Total Energy Efficiency Sector Jobs: 475,762					

Energy efficiency is also the workhorse of tackling climate change – the fastest, cheapest, smartest tool we have for reducing emissions. According to the International Energy Agency (IEA), energy efficiency alone must account for more than 40 percent of the emissions reductions needed to meet the goals of the Paris climate accord. Put another way, it's virtually impossible to achieve even modest carbon reduction goals without robust gains in energy efficiency.

But I want to be clear on this: Advancing efficiency at the pace required by the urgency of our climate crisis will certainly require sound policy. We did not get where we are without it, and we will not meet future goals without it.

In fact, we've recently seen some troubling indicators about our progress. IEA recently found that rising global demand drove a 2.3 percent increase in energy consumption last year, resulting in a 1.7 percent increase in carbon emissions globally and a 3.4 percent increase in the United States. This increase was partly due to the global economy and partly due to varying temperatures. U.S. energy consumption hit an all-time high of 101.2 quads. The demand for all sources of generation increased, yet energy efficiency gains saw only modest improvement. Similarly, the 2019 Sustainable Energy in America Factbook found that U.S. energy productivity – a measure of economic output per unit of energy consumed – ticked down by 0.4 percent as energy consumption outpaced GDP growth.

The good news is that the energy policy solutions, particularly in energy efficiency, double as powerful economic policy. To those wondering if we can tackle climate change while simultaneously strengthening our economy and global competitiveness, the answer with efficiency is a resounding yes. As I've mentioned, improving efficiency creates jobs, whether it's workers retrofitting homes and buildings or factory workers manufacturing high-efficiency windows, insulation, or air conditioners. Efficiency helps our manufacturers and other businesses grow faster and be more productive, and therefore making us more competitive globally.

Critical investments in energy efficiency R&D are the invaluable engine for innovation and technology breakthroughs here in the U.S., helping U.S. companies capitalize on growing global markets. But we often neglect to highlight the return on that investment. An independent evaluation of $12 billion of R&D led by DOE's Office of Energy Efficiency and Renewable Energy (EERE) showed that that investment yielded more than $388 billion in net U.S. economic benefits – again, according to third-party, peer-reviewed studies. That's an extraordinary return on taxpayer dollars, and a testament to American ingenuity.

And being a leader on innovation on efficiency technology and solutions means so much more. It means we can improve public health by reducing pollution and improving indoor and outdoor air quality. Efficiency can even significantly reduce government spending by increasing efficiency across local, state and federal buildings and operations. The federal government spends $6 billion annually

on energy in buildings – a number we could significantly reduce through smarter energy management. Last but not least, efficiency saves consumers and businesses hundreds of billions of dollars a year on reduced energy bills, money that can be reinvested throughout the economy. To date, across our collective energy efficiency gains, businesses and consumers are saving a staggering $800 billion a year[4].

I would note that these consumer savings are particularly important for rural and low-income households, which spend a disproportionately high share of their income on utility bills. The average U.S. household spends almost $2,000 per year on energy. According to Oak Ridge National Laboratory, the cost of energy represents an average 16.3 percent of the income of households making less than 200 percent of the poverty level versus just 3.5 percent of the income of households making more than 200 percent of the poverty level. These consumers often are pinched by the "split incentive" that exists when a landlord owns a house or purchases new appliances, but the utility bills are paid by the tenants. Efficiency policies are cost-effective, high-impact tools for reducing household energy burden. Minimum energy efficiency standards for common household appliances, for example, are estimated to save the average U.S. household $500 annually, amounting to an annual carbon reduction equivalent of removing 63 million vehicles from the roads. [5]

The good news of today's hearing is that there are many actions this committee can take to make the most of great opportunities to continue advancing energy efficiency and ensure the full range of benefits. In some cases, the committee could act immediately. In others, the legislative process will need to run its course. But given your past leadership on energy efficiency I am optimistic sitting before you today that together we can get the job done.

At the top of my list of recommendations for the committee is engaging in constant and rigorous oversight of the Department of Energy's (DOE) portfolio of energy efficiency programs. Most of the examples of progress I cited are a direct result of DOE's historical commitment to carrying out its duties, as authorized and directed by Congress, including setting and updating minimum efficiency standards, supporting state and local efforts to adopt and enforce building energy codes, and providing critical funds and technical assistance to state energy offices and local agencies responsible for delivering cost-effective savings to homeowners, consumers, and businesses. I am convinced that EERE's leadership and professional staff have the expertise and ability to do their job as Congress intended, but this committee can play an important role in making sure their work is done on time, in compliance with the law, and insulated from political interference.

Perhaps the most obvious examples of this need for oversight concerns the 16 energy conservation standards that have missed statutory deadlines and the ill-advised proposal to rollback lightbulb standards set to take effect in January. Many thousands of Americans submitted comments to DOE in opposition to the lightbulb rollback, yet the department continues to follow that route that will only lead to confusion and market uncertainty. This committee could help hold DOE to account for its

[4] "Energy Efficiency in the United States: 35 Years and Counting," American Council for and Energy-Efficient Economy, June 30, 2015, http://aceee.org/research-report/e1502. Last accessed May 17, 2019.
[5] "Appliance Standards Questions and Answers," Appliance Standards Awareness Project, 2017, https://appliance-standards.org/sites/default/files/Why_National_Appliance_Standards%202017_0.pdf. Last accessed May 17, 2019. "Appliance Standards Rank as #2 Energy-Saving Tool in US," Appliance Standards Awareness Project, https://appliance-standards.org/image/appliance-standards-rank-2-energy-saving-tool-us. Last accessed May 17, 2019.

decision to press on with a proposal that, by its own admission, will lead to a very preventable 540 million metric tons of carbon dioxide emissions by 2030 and cost consumers and businesses $12 billion. And their rationale is, essentially, a new belief that only now does DOE really understand the law as Congress intended and the department acted outside the limits of the statute when the latest rule was issued in 2017, which I find unconvincing.

When it comes to energy efficiency, delay comes at a steep cost in terms of never-realized savings and unnecessary waste. I know members of this committee have pressed DOE leadership on the status of the standards program, which is helpful and appreciated. I encourage your continued attention to this program and a fresh commitment to oversight in general to ensure that critical energy efficiency programs continue to generate economic and environmental benefits and DOE is carrying out the full range of R&D, development, and commercialization activities – including a timely deployment of funds for Weatherization Assistance and state energy office and funding opportunity announcements – with duly appropriated funds on an acceptable schedule.

I also respectfully encourage the committee to take up and pass bipartisan legislation to advance opportunities for energy efficiency in the buildings sector, manufacturing, and industry and ensure the federal government is leading by example, wisely spending taxpayer dollars, and managing energy waste in its own facilities. Much of these bills could easily pass as part of an "infrastructure" package. After all, infrastructure is more than roads and bridges – it's our utility grid, water and wastewater facilities, transit hubs, public buildings, ports, and other structures. These facilities use enormous amounts of energy, and a nationwide infrastructure initiative presents an opportunity to "get it right" and save consumers and taxpayers decades of wasted energy costs. In some cases, infrastructure projects can pay for themselves through public-private partnerships and innovative financing of energy savings investments.

As you continue to look at the possibilities of an infrastructure bill, I urge you to remember the importance of the built environment and its impacts on U.S. energy consumption. Existing homes and buildings – and new ones under construction – will be in use for decades to come, with enormous implications for U.S. energy consumption. The built environment currently accounts for about 40 percent of our energy use, and as with the transportation sector, innovation and technology are creating new opportunities for savings in residential, commercial, and industrial applications that can play a significant role in decarbonizing the economy. In addition to encouraging traditional efficiency solutions such as improved building envelopes and equipment, there are tremendous policy opportunities to pave the way for highly efficient homes and buildings through systems-oriented practices and technologies such as integrated design, active-energy management, internet of things, grid integration, and artificial intelligence.

Specifically, let me call your attention to three bills that would deliver savings and help lower greenhouse gas emissions. The first is the Energy Savings and Industrial Competitiveness Act, more commonly known as the namesake of its sponsors, Senators Rob Portman (R-Ohio) and Jeanne Shaheen (D-N.H.). The Portman-Shaheen energy efficiency bill is supported by a broad and diverse coalition of energy, industrial, and environmental stakeholders. Moreover, this committee has approved the legislation in the past on an overwhelmingly bipartisan basis. Many current committee members were cosponsors of the bill when it was last introduced, about two years ago. And this bill was the first title of S. 2012, the comprehensive energy bill from the 114th Congress, that was passed

by the Senate 85-12 in April 2015. It means a lot when this committee chooses energy efficiency as its best foot forward in comprehensive energy bills. The Portman-Shaheen bill is not yet introduced this year, but I know committee staff is working hard with the sponsors with the goal of introduction soon in the 116th Congress. I urge your prompt consideration of this bill, which has long been a top priority of the Alliance, at the earliest opportunity.

A second bill worthy of the committee's support is S. 1245, the All-of-the-Above Federal Building Energy Conservation Act, sponsored by Senator John Hoeven (R-N.D.) and Ranking Member Joe Manchin (D-W.Va.). The Alliance has supported this legislation in the past. But what makes this bill so important are the forward-looking energy intensity reduction targets that would drive energy efficiency improvements in federal buildings. This bill would push the federal government to lead by example at a time when the administration is backing away from making cost-effective improvements to its facilities. Much of the gains of this bill could also be accomplished with little impact on taxpayers by leveraging public-private partnerships, including performance contracting, so that savings from energy efficiency measures are used to pay for the investments. To date, performance contracting has helped spur more than $5 billion in energy efficiency improvements in federal buildings and saved more than $12 billion in energy costs. It's an incredible vehicle that saves energy, saves taxpayers money, and, on average, creates nearly 100 jobs for every $10 million in federal performance contracting. That's why we're thankful for the willingness of the sponsors of S. 1245 to work with us as part of a diverse coalition of utilities and businesses on a bill that would lead to significant savings and quantifiable carbon emissions reductions.

Third, I urge your support for S.983, the Weatherization Enhancement and Local Energy Efficiency Investment and Accountability Act. This bill, which was introduced by Alliance Honorary Advisors Senators Chris Coons (D-Del.) and Susan Collins (R-Maine), also enjoys strong bipartisan support. Special thanks to Chairwoman Murkowski and Ranking Member Manchin for your cosponsorship of this important bill as it has been improved over the years. This bill would strengthen the Weatherization Assistance Program, an already-successful program that supports 8,500 jobs, reaches 35,000 households each year, and reduces a family's annual utility bills by an average of $283. This program has already helped seven million families. Your approval of S. 983 would help the program help even more going forward.

In closing, I would like to emphasize the opportunity before us if we take aggressive steps to advance energy efficiency. Yes, we must work on energy supply and power generation. But there is an energy goldmine on the other side of that equation – the demand side. It doesn't require sacrifice or reducing our economic output. It simply requires doing things smarter, and yes it requires investment and it requires policy.

I tend to say, "I could go on" a lot when it comes to energy efficiency. And that is because the opportunities of energy efficiency are practically boundless. I'd also like to mention that I appreciate Senator Ron Wyden's (D-Ore.) interest in exploring the potential for systems efficiency in commercial buildings. This is one area of energy efficiency policy, which the Alliance has developed in close partnership with many of our private-sector Associate members, with the potential to lead to much greater market acceptance of leading-edge systems efficiency and controls technologies. And lastly, I would like to recognize Senator Gardner's (R-Colo.) continued support for the use of performance

contracting to improve energy efficiency in federal buildings by leveraging private-sector capital. There's simply no shortage of good ideas and sound policies that this committee could act on that would deliver even more of the full range of benefits of energy efficiency.

My friend Amory Lovins, thought leader on energy efficiency and founder of the Rocky Mountain Institute in Senator Gardner's home state of Colorado, talks about this opportunity at this moment in an interesting way. If we found a massive new oil reserve tomorrow, it would be all over the newspapers and the nightly news. But the enormous potential that technology is unlocking for energy efficiency – through smart meters, smart buildings, materials innovation, connected devices and other innovation – is a greater opportunity than any oil discovery. While the innovation of efficiency is sometimes hard to see, the opportunity is real and right in front of us – uniquely able to drive economic development, create jobs, save Americans money and protect the environment.

I urge you – and the Alliance stands ready to work with you – to keep our focus on energy efficiency as America's greatest energy resource, what IEA called, "the cornerstone for building a secure and sustainable energy system."

Thank you again for inviting me to testify. I'm happy to take any questions you might have.

The CHAIRMAN. Thank you, Dr. Hartke.
Mr. Grunau, welcome to the Committee.

STATEMENT OF BRUNO C. GRUNAU, CHIEF PROGRAMS OFFICER, COLD CLIMATE HOUSING RESEARCH CENTER

Mr. GRUNAU. Good morning, thank you, and thank you, Senator Murkowski, for the opportunity to come up here and share our story with you and the rest of the Committee and these really talented folks here on this panel.

Our mission at the Cold Climate Housing Research Center is to advance energy efficient, sustainable, durable and sustainable shelter throughout Alaska and across the circumpolar North. And the way we do that is through advancing applied research and innovation through demonstration.

As Senator Murkowski mentioned before, one of our accolades is that we're able to work with communities, take a holistic approach of working with some of our communities across Alaska to design culturally appropriate and energy efficient homes that use 80 percent less energy than their neighbor next door at the same or less construction cost of the neighbor next door.

We also have a 25,000 square foot research test facility. It's the farthest north LEED Platinum building in the world, and we're proud of that.

We also work with communities across Alaska to help with climate change situations. The community of Newtok, for instance, is falling into the sea, so we're helping them rebuild, working with them to rebuild their community in Mertarvik and make sure they have good energy efficient homes.

I know a lot of times when we look in the Lower 48, we talk about building advancements and, quite frankly, in Alaska, that's just a way of life for a lot of our builders. In a lot of ways, we're building houses today as we did 50 or even 100 years ago and buildings do take up about 40 percent of our nation's energy. And that's just a huge untapped potential out there to lower energy demand.

And as I heard Senator Manchin say before, energy efficiency really is the low-hanging fruit. In fact, it's the backbone really on which we can build our renewable energy infrastructure.

The thing about energy efficiency is it doesn't quite have that shine that renewable energy has, you know? You put a solar collector on a roof, you're making a statement. People can see it and people can see your values, but energy efficiency, not quite so much.

And again, you have two houses that look identical, one can pay two or three times the amount of energy that the other does and the only thing to show for that are energy bills.

Demonstrating what's available really is the key. If you come in—and I invite everyone here to come to the research center—I'd love to give you a tour. We would give you a tour of ground source heat pumps that work in permafrost, our photovoltaic systems and what we know about how they work up in Alaska. A seasonal thermal storage energy system that we've got, and we can show you all those things.

But if there are three things I'd want you to walk away with is that when you build your house, you want a good energy, a good building envelope that's the right amount of insulation of the right configurations. You want it nice and tight, and you want good ventilation. Those are the three most important things that achieve energy efficiency. And all of that combined doesn't just impact energy bills, it also impacts health. If you build the building right, then you're going to create a house that has less mold, better air quality and reduce costs, health costs, to the state.

As a matter of fact, in rural Alaska we have some of the highest, the highest incidence of respiratory infection in the country. One hospital visit in rural Alaska due to unhealthy housing, by the way, is about $22,000. That's work that came out of Alaska Native Tribal Health Consortium here this year.

And since we're on money, we can talk about economic impacts. In Alaska we had a ten-year program, it's called the Home Energy Rebate Program. It was a $242 million program using existing technology and it covered about 26,000–27,000 homes. But with that $242 million investment, it resulted in reduced energy costs of $261 million. It reduced the energy of those homes by 34 percent. It reduced greenhouse gases by 3.2 billion pounds of carbon dioxide. It stimulated 7,000 annual jobs and over $900 million in economic stimulus. It's almost $1 billion, and the state has about a $4 billion annual budget. It's huge.

Other opportunities that we can increase energy efficiency is through LED lighting, as was mentioned earlier. We found that we estimated about $20 million of annual savings can be achieved by upgrading from linear fluorescents to LED lighting just in our public facilities in Alaska.

But since we're here to talk about energy efficiency, I really wanted to underscore that part of the advancements of energy efficiency is getting the mechanisms out there to use what's available.

But as far as what's ahead of us, there are two technologies I'd like to highlight. One is air source heat pumps. Air source heat pumps are changing right now. You can get air source heat pumps on the market that work to minus 15 degrees Fahrenheit. It's incredible. We worked with Oak Ridge National Laboratory a couple years ago, two years ago, and demonstrated an air source heat pump that worked at minus 25 degrees Fahrenheit. That's pretty impressive.

I know in Kotzebue, a small rural community in Northwest Alaska, there's a demonstration project where we're incorporating air source heat pumps and it's calculated to, when you use the air source heat pumps in the shorter seasons, it's calculated to reduce the total energy cost by about 30 percent. So that's a big deal.

And then the last thing, really what we need in terms of advancing energy efficiency is to evaluate, research and demonstrate these new building technologies and building materials that are out here.

I brought one example with me today. This is a vacuum insulated panel. It has an R value of R–60 per inch, R–60 per inch. Your 2x4 wall with fiberglass is about R–11. It's a game changer, quite frankly. With materials like this we just have to figure out, and I'm happy to pass this around, we've got to figure out ways to

integrate this into our buildings. Some commercial uses are starting to use this, but we need to get these into our homes now.

Quite frankly, I think that if we stay on this path it won't be long before we look back and we'll be appalled at how in 2019 we had used 40 percent of our energy on buildings.

So anyway, I'm looking forward to the opportunity to talk with you all, and thanks for the opportunity to be here today.

[The prepared statement of Mr. Grunau follows:]

Testimony for the Record
Prepared For the U.S. Senate Committee on Energy & Natural Resources

For a Hearing to
Examine Opportunities to Advance Renewable Energy and Energy Efficiency Efforts in the United States.

Presented by
Bruno C. Grunau, PE, Chief Programs Officer
Cold Climate Housing Research Center
Fairbanks, Alaska

May 21, 2019

Introduction

Thank you, Chairman Murkowski, Ranking Member Manchin, and the Members of the Committee on Energy and Natural Resources for the opportunity to have a voice and to contribute to advancing renewable energy and energy efficiency in the United States.

The Cold Climate Housing Research Center (CCHRC) was founded 20 years ago as a 501(c)(3) not-for-profit organization by members of the Alaska State Home Building Association, professionals in the home building industry statewide. The mission of the organization is, "promoting and advancing the development of healthy, durable, and sustainable shelter for Alaskans and other circumpolar people." Applied research that addresses the myriad challenges of building in Alaska are prioritized through research advisory groups statewide, from Ketchikan to Utqiagvik (formerly Barrow). The advances in building science over CCHRC's history have improved the energy efficiency, mechanical systems, foundations, material selection and development of buildings well beyond Alaska. Our contribution to the building industry is recognized nationwide and globally.

Alaska: A proving ground for Energy Efficiency

Alaska presents some of the most extreme and varied environments on earth, from the arctic tundra to the Bering Sea, with hundreds of villages that are inaccessible by road and located far away from energy resources. In this environment, shelter literally means the difference between life and death. Compounding these challenges is the fact that Alaskans face the highest energy costs in the nation. These challenges have helped make Alaska a world leader in energy efficient building and building technology. We would like to share several of the lessons we have learned in the world's most challenging environments.

Good housing is essential to a safe and healthy life. Yet in Alaska, tens of thousands of homes are cold, under-ventilated, and extremely inefficient. Rather than providing refuge from the elements, a large portion of the housing stock has become a financial burden and an actual health hazard to occupants. Unfortunately, people with the fewest resources are impacted the most, including Alaska Native infants and elderly, who suffer from the highest rates of upper respiratory disease in the country due to unhealthy housing.

Throughout Alaska, CCHRC has established a holistic approach with communities to design and build energy efficient, affordable demonstration homes using local labor and traditional knowledge. Thoughtful design informed by indigenous populations with deep knowledge of their local environments has resulted in energy efficient, healthy homes with lower construction costs. These homes use less than half the energy of typical homes in the same communities and are healthier and more durable.

CCHRC's deep experience working in both urban and rural Alaska has shown that building healthy, efficient homes is one of the best investments we can make. Using proven building science and rigorously tested materials, we can dramatically reduce energy use while ensuring healthy indoor air quality for residents, with little or no additional upfront cost. This applies not only to homes but to commercial and public buildings as well. For instance, CCHRC's facility in Fairbanks is the farthest-north LEED Platinum building on earth. It was designed and built to meet these standards at a cost equivalent to other commercial buildings in the region through close collaboration with the builders, designers and engineers, creating a cohesive team approach.

Cold Climate Housing Research Center Research Test Facility, 2018.

How has CCHRC advanced Energy Efficiency & Renewables in Alaska?

CCHRC works in all regions of the state to ensure that homes are affordable to build and to live in. This begins with research that focuses on testing and vetting viable building technologies. In

the lab, we study everything from foundation and walls to heating and ventilation systems. The lessons learned are applied to homes CCHRC designs in all regions of Alaska.

On average, CCHRC demonstration homes use 80% less energy while also reducing construction costs. These results are achieved through community engagement, thoughtful design, careful selection of materials and shipping options, and utilization of local labor and workforce training. This "holistic approach" to design and construction incorporates the latest building science with the invaluable knowledge of First Alaskans accumulated over thousands of years of successful adaptation. All building designs have mechanical heating and ventilation systems that ensure healthy indoor air quality without sacrificing energy efficiency, resulting in healthier families and communities.

In addition to testing and design, economic and policy research helps us understand the housing challenges and focus on data-driven solutions. Every four years, CCHRC conducts a housing assessment looking at size, cost, energy use, and condition of more than one-third of all homes in Alaska. From this work, we know that 40% of Alaska's housing stock is aging and in need of a retrofit, and more than half of homes are under-ventilated and at risk of poor indoor air quality.[1] This informs policy makers, funders, and planners who set priorities for the state. We also measure the impact of energy efficiency on homeowners and the economy as a whole. For example, a $242 million state-funded program that incentivized Alaskans to make energy efficiency improvements resulted in $260 million in energy savings for homeowners over 10 years, an estimated 1.6 million tons of reduced carbon dioxide emissions, nearly 7,000 annual jobs, and $912 million in economic impact.[2] Through this program, the average household cut energy use by 34%, savings that will continue for the life of the house. This type of research shows not just the exceptional economic impact of energy efficiency but also the public demand for it.

Working with federal agencies to advance Energy Efficiency in Alaska

CCHRC has longstanding partnerships with federal agencies to ensure the dollars spent in Alaska provide the most benefit to Alaskans. While housing issues span the state, the needs are most acute in rural villages, where there is a legacy of failing structures built by outside entities that have become a burden to heat and maintain. The typical rural household spends over $5,000 per year on energy, with some regions averaging $6,427, nearly three times the national

[1] Wiltse, Nathan, et al. "2018 Housing Assessment." Alaska Housing Finance Corporation, Mar. 2018, https://www.ahfc.us/efficiency/research-information-center/alaska-housing-assessment/2018-housing-assessment.

[2] Wiltse, Nathan, et al. "State of Alaska - 2019 State of the State." State of Alaska | Cold Climate Housing Research Center, Jan. 2019, www.cchrc.org/soa.

average.[3] Overcrowding rates in some rural regions are as high as 40%, and unhealthy indoor air quality is a widespread problem.

The goal of every CCHRC project is to make communities stronger, more resilient, and more affordable. Because many rural residents depend on subsistence activities more than conventional jobs, they have limited access to traditional financing options for energy and housing projects. These basic services are typically provided by public programs and often via competitive grants, which are difficult to navigate and understand for people with a different culture and sometimes a different language. CCHRC partners with rural communities to overcome these obstacles. Thanks to capacity-building programs such as those supported through the Department of Energy's Office of Indian Energy or through the Alaska HUD Office of Native American Programs, we provide technical assistance to these communities in applying for grants, developing energy action plans, and providing expertise on energy efficiency and housing projects.

CCHRC has designed more than 20 super-efficient demonstration homes in communities throughout Alaska, working directly with local people to ensure they are appropriate for the climate and the culture. Through funding from U.S. HUD and others, we have developed these homes in Quinhagak, Buckland, Anaktuvuk Pass, Venetie, and others using indigenous wisdom and 21st century building science. For example, a demonstration home on the North Slope slashed energy use from over 1,000 gallons of heating oil to less than 200 gallons per year, and incorporated a standalone sewage treatment plant that saved roughly $50,000. The home's efficient envelope and building systems were repeated by the regional housing authority and stimulated $12 million in new construction to provide much needed housing in North Slope villages.

Since 2011, CCHRC has partnered with the Federal Emergency Management Agency (FEMA) and other emergency responders to create quick, deployable homes that are appropriate for the region. These designs leverage the best building science with an understanding of the logistical challenges of rural construction. When the village of Galena was devastated by Yukon River flooding in 2013, CCHRC worked with FEMA to design a home that could be built rapidly by unskilled labor and developed a staged training program for volunteers. Five super-efficient homes were created to replace those lost in flooding. These permanent homes were built within 20% of the value of the temporary homes originally planned which also saved the required federal cleanup cost to remove the temporary homes.

[3] Wiltse, Nathan, et al. "2018 Housing Assessment." Alaska Housing Finance Corporation, Mar. 2018, https://www.ahfc.us/efficiency/research-information-center/alaska-housing-assessment/2018-housing-assessment.

Yukon River Flood, Galena, 2013. Photo Courtesy National Weather Service.

CCHRC supports U.S. Department of Energy's efforts to lower energy costs in rural Alaska. Through a tribal lands grant, we are helping four communities improve the energy efficiency of their buildings through energy planning, training, and retrofit measures. This program, which was funded by the DOE's Office of Energy Efficiency and Renewable Energy, not only produces actionable plans but also helps communities understand long-term ways to lower their overall energy use. Once energy efficiency and conservation steps are taken, communities can move on to possible renewable energy systems.

The U.S. Department of Defense uses CCHRC as a resource for its military bases and Arctic infrastructure. With billions of dollars of infrastructure in America's coldest region, Army officials are collaborating with CCHRC to improve energy efficiency and reduce operating costs. Working with the Alaska Center for Energy and Power at the University of Alaska Fairbanks and the Cold Regions Research and Engineering Laboratory, CCHRC is evaluating energy efficiency and energy conservation measures on Fort Wainwright in Fairbanks. This includes testing and

developing heat pump and heat recovery ventilation technologies to see how they can be used at military sites and other cold climate applications.

A Changing Arctic

One of the most pressing national security issues is climate change. With Alaska warming much faster than the rest of the U.S., our military sites are facing increased flooding, wildfires, and degrading permafrost while our communities face threats to their security and subsistence lifestyles. In some cases entire villages are being forced to relocate due to thawing permafrost and erosion. Newtok in southwest Alaska is disappearing faster than any other. For over a decade, CCHRC has been helping the community in the difficult process of moving to a nearby island. The challenges of relocation are daunting: there are no roads or airstrips on the island; no barge landing or staging area; no power; no school, store, or post office. The wet, windy climate is very hard on building structures. Questions of funding and local politics only add to the complexity.

This type of project is the norm in Alaska, and it is the reason CCHRC exists. Our building scientists and architects are designing homes and utilities for the new village using a holistic approach that engages the community. The first step was a Housing Master Plan where we conducted interviews with every Newtok household to determine number of homes needed, floor plan preferences, fuel preferences, options for accommodating elders, and more. Following multiple community meetings, the team designed a three-bedroom house with thick walls and fiberglass insulation that can resist the Bering Sea weather. It has ample food storage to meet the hunting and fishing lifestyle. A waterless toilet and gravity-fed water system was developed by CCHRC and the Alaska Native Health Consortium for villages like Newtok that currently rely on hauling water and going to the bathroom in 5-gallon buckets. The home's integrated heating and ventilation system was also developed by CCHRC to ensure airtight homes like this one receive adequate fresh air.

The challenges facing Alaska and the United States require a truly holistic approach. CCHRC works on a foundation of community engagement, leading-edge building science, and an instinct to learn from the past and try new things. As communities across the nation are forced to adapt to changing times, CCHRC is poised to help.

Mertarvik: the New Home Site for the Community of Newtok, 2018.

Transition to Renewables

It is clear that energy efficiency offers the greatest return on investment for governments and individuals, and spreads benefits to consumers, communities, and the planet. Once we have addressed the energy demand of buildings, the next step is thinking about intelligent supply. Alaskans rely heavily on diesel, coal, and natural gas for heat and power, and the environment poses unique challenges for renewable energy. Technologies that are well established in much of the country still face barriers in the north. For example, the extreme angle of the sun and the short winter days provide additional obstacles for solar energy, while cold ground temperatures reduce efficiencies of geothermal systems. As renewable power generation capacity increases for these Alaskan communities, advancements in microgrids and smart-grid technologies are essential to balance variable renewable power sources with less variable fossil-fuel power generation systems.

CCHRC tests these technologies in Alaska's various regions to find opportunities for homeowners to save money. In Southeast Alaska, for example, our research shows that the average household with electric heat can save $5,000-$10,000 by installing an air source heat pump (over the life of the equipment). In Interior Alaska, we know solar photovoltaic systems pay back in 7 to 9 years through offsetting expensive electricity. And we are testing ways to use thermal storage technology coupled with solar and biomass systems to bridge time periods without sun, improve air quality, and use our resources more efficiently.

The Path Forward

The Cold Climate Housing Research Center is dedicated to advancing energy efficiency and affordable energy solutions for people of Alaska and the circumpolar north. What we've learned the past 20 years in the world's harshest climate can be applied to the diverse climates of the continental United States.

It is obvious to all sectors of the building industry that energy efficiency is the "low-hanging fruit." It is important that research to improve building performance, building longevity, and occupant health be prioritized in any national energy plan. Science has shown that mechanical systems, foundations, glazing, and the development of advanced materials has dramatic results. Incorporating renewable energy systems as part of the whole building envelope to actually create structures that generate as much energy as they use has been shown in other countries to be practical and affordable.

It is the task of the Senate Energy and Natural Resources Committee to find a clear direction forward in addressing urgent needs in the built environment. We feel that our organization has consistently demonstrated that success is attainable, affordable, and practical. We are honored to be a part of the discussion and hope each of you will remember that the progress being made in your farthest-north state (Alaska) is something we sincerely want to share.

The CHAIRMAN. Thank you, Bruno.

I know that Senator Manchin has a question. He says, how do you keep it tight and ventilated, but we know that that has been one of our challenges and you all have really pioneered it.

I am going to defer my question here to allow Senator Gardner to go first.

Senator Gardner.

Senator GARDNER. Thank you, Madam Chairman, and thank you to the witnesses, again, for your time and testimony. I appreciate the ability to ask questions now so we can go off to another committee.

Dr. Keller, as households and companies reap the benefits of innovations you talked about in your opening statement, particularly in distributed energy resources—rooftop solar, smart efficient devices—it increases the number of access points for cybersecurity concerns, as you talked about.

Could you talk a little bit more about the collaborative efforts to conduct both the DER, Distributed Energy Resource, research and cybersecurity research that is being done at NREL or other national labs? Could you talk a little bit about that and just talk about how we "bake in" cybersecurity into our research and development so that when it is good to go, it is good to go security wise as well?

Dr. KELLER. Thank you, Senator.

You bring up a very, very important topic, and I tell you this, when people ask me what keeps me up at night, this is exactly one of them. When you see how we are moving with our grid architecture, that there's all these changes, that we have a more distributed grid—a grid will go bidirectional. People—you know, when you have solar panels you want to check what you're using, how much you produce, and so on. So suddenly you're recreating a lot of new vulnerabilities for our security and cyber elements which we did not have a couple years ago.

And that's why we are reaching out. Historically, NREL probably was not known to be in the cyber world. But that's what we felt was a very, very important element to move into the space, partner with other national laboratories such as Sandia or Oak Ridge or Idaho to come from the distributed side and help how we can close this gap.

I think the cybersecurity outlook is changing right now. We are pretty good to secure the grid as we have it right now. But the grid of the future will be very different, and that's where we need to also develop new cybersecurity measurements.

I've been working on what you call autonomous grid systems. So the future of the grid will very likely be driven by machine learning or by artificial intelligence which will enable a lot of new control mechanisms for the grid. This said, it also will bring new threats to the grid and that's why we have to be ahead.

And may I say this, when you work in cyber, the problem is you're on this journey but you will never reach your goal because it's constantly evolving. You always have to be ahead and that, in my view, will be, will keep the researchers here very, very busy, the scientists, for a long time to come.

Senator GARDNER. Very good, thank you and congratulations on the $100 million agreement with NETL and Exxon Mobil. I think this is an incredible opportunity. And thank you for the collaborative research and development effort, the approach for R&D that you have taken at NREL, our labs and other universities.

What does this mean? I mean, how does this work and what does this do to DOE? Does it take it in a different direction? Does it continue to fulfill the mission? What does this agreement mean to you?

Dr. KELLER. So we are very excited about this agreement. We just had the official signing ceremony earlier today at DOE headquarters.

This is where two or three parties are coming together which brings a lot of new ideas to this. I mean, when you look at our research and what Exxon Mobil is very, very good at is how you scale things into the market.

So when you look into the new lower emission technologies, a lot of times universities and the schools like to do the work on the very small scales. And then the question is how do you take the small scales and how to scale it that they have an impact in our economy and the resulting industry?

And this is what this agreement will do. That's also why we have this ten-year agreement that you can start at low tier levels with brand new ideas but then the agreement is to bring people from the national lab complexes. It's beyond even NREL and NETL, we are also reaching out to Idaho and to any other national laboratory that has great ideas. We're also going to reach out to academics with great ideas to bring them in and then work together in this—how can you take some of this early stage research and how can you scale it together with the engineers from Exxon and our scientists.

So, our scientists, we're excited about this because suddenly you can have an industrial partner who knows exactly what is relevant, what we can do by bringing this together, working as a team to take this and scale ideas.

Senator GARDNER. Thank you.

Dr. Hartke, thank you very much for the shout out of the Energy Savings Performance Contracting legislation. Senator Coons and I do plan to introduce that in early June. Obviously interested in the efficiency issues both from an economic and environmental perspective, the EIA has singled out energy efficiency as contributing more than 50 percent. I think this is an incredible statistic. The EIA has singled out energy efficiency as contributing more than 50 percent of our nation's reduction in carbon emissions over the past decade.

So this is something that is not just a tool for people to save a little bit of money. We have actually reduced carbon 50 percent because of energy efficiencies. And we can do a lot more than just what we are doing right now. And that number, that 50 percent reduction, is more than fuel switching and renewable energy generation combined. So that is a pretty powerful tool that we have been able to capture with a lot more work and potential.

Could you talk a little bit—I guess I am out of time. So we will carry this conversation on at some point. I got excited here, sorry about that.

And Dan, certainly thank you for the work you are doing on the Flat Irons campus as well.

Thanks very much.

The CHAIRMAN. Dr. Hartke, if you want to give a quick response to that? I mean, this is——

Senator GARDNER. I didn't get my question out, so——

[Laughter.]

The CHAIRMAN. Well, I know but, we kind of knew where you were headed, Senator Gardner.

Dr. HARTKE. Well, it is a tremendous statistic. And I think that, you know, federal buildings account—we pay $6 billion a year on utility bills for federal buildings alone.

So federal buildings ought to be a leader. There's an amazing tool that you know all too well in energy service performance contracting (ESPC) that is an amazing deal for the American taxpayer. Doesn't cost them any money to do these energy improvements.

Those energy improvements work. They save taxpayers money, and they make sure that we're leading on energy efficiency and other clean energy solutions which is exactly how it should be.

In addition, there's other statistics that show, I think, for every $10 million invested through ESPCs, we're creating 100 jobs. So all that investment that we're doing that doesn't cost the taxpayer any money, in fact, saves them money, is creating jobs.

So, I would, you know, do agree that we're in whatever gear. If we can get into a higher gear on those types of solutions, that's exactly what we should be doing. I mean, it really is a tremendous solution.

The CHAIRMAN. Thank you for that, Dr. Hartke.

I do think we recognize that we have an extraordinary opportunity to lead with our federal buildings. I happen to think that we are lousy in this category.

I know that we have done a good job with the lights, but I think when we can figure out how to get men's summer attire just a little bit loosened up then we won't require so much air conditioning.

Senator HEINRICH. I am with you.

The CHAIRMAN. And the women can be a little more, I guess, we don't need space heaters under our desk in order to wear a summer dress.

So know that this is my little mission. I have not made much headway with it but, by gosh, when you guys are wearing long sleeve shirts, undershirts, ties, socks and leather shoes and it is 90 degrees, it does not make sense. I am just saying.

Senator GARDNER. Madam Chair, unfortunately, the hot air in Congress is anthropogenic.

[Laughter.]

The CHAIRMAN. Okay, let's go to Senator Manchin.

Senator MANCHIN. ——to Senator Heinrich, who has another commitment.

Senator HEINRICH. I will start by saying, sign me up for the no tie caucus. I am with you.

I think, first, we should say that the cheapest energy around is conservation, right? The kilowatt-hour, the megawatt-hour that you don't have to pay for is the cheapest energy out there.

I want to go from that to what is next cheapest and this is a little chart I had on my desk this morning, so I grabbed it and I modified it with updated data and brought it over.

[The chart referenced follows:]

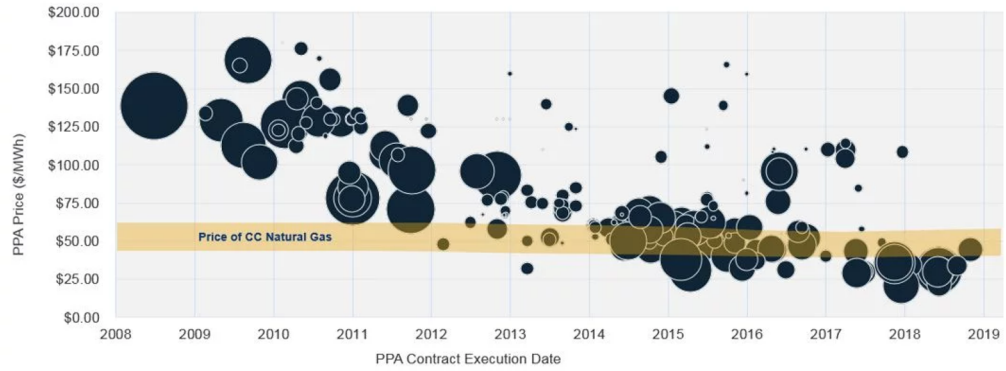
Solar ITC Stepdown Forecast and Strategy

woodmac.com

PPA prices by contract execution date

Utility PV PPA price is consistently below the price of new build CC natural gas

Pricing for power purchase agreements has ranged between $25 and $45/MWh for contracts signed over the past 18 months
Opening up new origination opportunities beyond procurement to meet Renewable Portfolio Standards



Source: Wood Mackenzie Power and Renewables

Senator HEINRICH. Basically, what it shows is the trend line of how PV renewables have gotten cheaper over time and where we are on a levelized basis between nuclear and then coal and then combined cycle natural gas and now, renewables dipping below that.

So the challenge is not so much, at this point, the economics of decarbonizing our grid. It is how do we manage that grid to maximize its resilience to make sure it is reliable and to maximize penetration.

I wanted to start by addressing something that Mr. Simmons brought up which is this idea of using our existing storage in hydro as more of a storage resource. In the past we really have not done that. We have managed it very differently. We need to think about how we use that resource to really balance the grid in contrast to how we have used it historically. I would just ask you, what are the policy changes that need to happen for that to change? And do we need to change our rate structures to support that kind of a change?

Mr. SIMMONS. Thank you for that question.

Last week I had the opportunity to attend the World Hydropower Congress, and much of the discussion there, much of the focus, was how can we use hydropower better? "We," being the world. How can we use hydropower better to balance the grid of the future?

And there was a lot of discussion around this. I don't know if we need, necessarily, new policies. However, what we need to understand and what people that run the grid need to understand are the value of the different types of generating resources.

In the past a pumped hydro facility may run twice a day. Some of these facilities are now being called on 60 times a day. But even if I remember that wrong and it's only 30 times a day or only 10 times a day, that's still many times more than it has been in the past. So this is some important research that we are doing, both understanding how that changes the operation of maintenance of those sorts of plants.

But also some of the other important research that we're doing is trying to understand value to the grid that hydro and other types of generating services provide.

Senator HEINRICH. Is either NREL or DOE, writ large, really diving deep at this point on how we can also bring to bear new tools like AI and machine learning to balance that grid on a moment-by-moment basis?

Mr. SIMMONS. Without a doubt, and I'll definitely let Martin talk to that.

Dr. KELLER. So we're looking into this again. When you look into the future, we will have tens of millions of devices on our grid which you can control. All this will be power electronics. There was even a light bulb, but it will be power electronics.

Senator HEINRICH. I heard what you can do with 100 water heaters. Imagine what we could do with tens of millions of devices.

Dr. KELLER. Correct, correct.

The problem is right now that we don't have the tool actually to use in these devices to control the grid. When you look and extrapolate this out, maybe controlling our grid will not work for so many devices. And that's why we engaged into this what we call

"autonomous grid." There's a researcher who would say, how could you bring some new algorithms, some machine learning tools into this that you can use actually all these devices to come up with the grid architecture and do the grid control mechanisms for the future? This is what we engage in right now.

Senator HEINRICH. I am going to run out of time quickly as well, but Dr. Keller, talk to us a little bit about perovskites. You mentioned them in your testimony. Where are they on the path to commercialization and why does it matter?

Dr. KELLER. So, perovskites is a very interesting molecule because if we can work out, I mean there's still some research topics we have to overcome, the biggest one is still stability. So perovskites are known that they are sensitive to moisture so they're losing their effectiveness over time. If you, assuming we can overcome this issue, suddenly it would open a completely new way of manufacturing solar panels in the future.

So we always talk about this, they can use perovskites almost like you have solar panels. You would make them like you make newspaper. It's an ink. You can spread them out. They're a very thin film. And this can open up solar to everything. So we could have solar in every device, in also, especially for our defense. It's very important for fort bases. It's very lightweight.

Senator HEINRICH. Clothing, backpacks, tents.

Dr. KELLER. Correct, everything. It's completely flexible.

So this can be a step function revolution, how we make solar panels in the future.

Senator HEINRICH. Thank you.

The CHAIRMAN. Thank you, Senator.

Mr. Grunau, and this will also be to you, Dr. Hartke, and pretty much anybody here on the panel. We had good discussion today in highlighting the reduction in energy cost to families as a result of gains that we are making in efficiencies.

When we think about those who are most impacted by the higher cost of energy, it really is the most vulnerable in our society, whether it is elders or the poor. And when we have some important federal programs, the Weatherization Program has been mentioned, we see great benefit of that in Alaska. We have state energy programs. Those programs that can help maximize efficiency standards.

But if you had your magic wand here in terms of the area that you could make the biggest impact on effectiveness from the Federal Government's perspective in helping low income households reduce energy costs, where is it?

You know, in a cold place like Alaska, it seems to me, the easy place is the weatherization and the insulation so that you don't have to spend so much more. Maybe in the south, it is you don't, again, these efficiencies allow you to live more comfortably, not die of heat stroke in hot places. Where is the most exciting potential that you think we have a role to play from the Federal Government's perspective that can make a difference for those that are more energy vulnerable?

Bruno, do you want to start?

Mr. GRUNAU. I'm happy to go first. That's a great question. I really appreciate that.

You mentioned the Weatherization Program, and it is absolutely a great example of what does work. It hits the low-income bracket because I think the average income for that program is like $28,000 a year. So that really does work out well.

There's a gap of folks who, kind of, need the help who can't afford, say, that home energy rebate program we've got.

The CHAIRMAN. Right.

Mr. GRUNAU. There are folks who can afford that. There are some who go into that program and they can't afford the whole retrofit process. And so, those are people that we kind of need to help, sort of, support.

I want to just build on the backs of some of the programs that EERE and the Office of Indian Energy have put out that's actually helping rural Alaska build capacity in a lot of rural communities there.

So what I mean by that is, in fact, there are people in town right now, this week, presenting on the outcomes of some of these projects where we go into the villages and we do energy audits for tribal buildings. And then that gives them an energy plan to help move forward. I think that's a big step forward.

It's kind of like, you know, in your own home you know a couple things you could do to make your house more efficient, but really you need pros to come out there. And so, that's where, I think, that's a magic wand thing I would like to say is support continued programs that help that endeavor.

I'd also say just education, education of the, not just homeowners, but homebuilders. If we can get some of these technologies, and I'm talking just basic building methods that are energy efficient, into the hands of our builders and maybe through codes. I mean, that's a great one because, of course, Alaska doesn't have statewide codes.

The CHAIRMAN. Let me ask about that one, and I will open this up to everybody because I think it was you, Dr. Hartke that said, we don't always see the benefits of efficiency but it is clear that the opportunity is there. I thought that that was well put. And it goes back to education.

So much of this is people just don't know how they can make a difference or they say, me changing out my light bulbs to LED, that is not going to make a difference. I am not going to be able to change the world or save the world today.

So in addition to the magic wand, because I agree, education has to be a significant component of this. The Alliance to Save Energy, I mean, that is kind of what you do, but we are not doing it enough if we are still seeing 40 percent of the power generation that is going toward our buildings. What do we need more there?

Dr. HARTKE. I'll just chime in quickly, a couple points.

One, and this speaks in part to your question which is a big, big question. Since the end of 2017 we have not had incentives for energy efficiency. They expired at the end of, you know, now almost a year and a half ago. And making sure that we are continuing to drive behavior toward high-performance products and homes makes a difference. I think it's a market signal that reaches everybody.

On the flip side, how do you have a policy, a Federal Government role that does reach everybody? I don't think there's any better example than standards. Standards has been an engine for innovation and a program, I mean, one of the greatest energy efficiency polices ever completed, it's now saving us over $2 trillion. And that reaches everybody.

Because the problem, I think, with your question is how do you construct a policy that does get to the folks who would benefit most from those energy savings? And that's tough to do in part because there are a variety of structural barriers and there's split incentive barriers.

So it's hard if you're a tenant or you're a renter, you might want to have more energy efficiency and benefit from those energy savings, but they would actually go to the landlord. So how do you overcome those barriers is a big deal.

And then last, I would just underscore the role of education. It's huge.

I just saw this full spread piece in the Washington Post that was talking about all these home retrofits and retrofits that you could do. You could do your bathroom, your kitchen, all these other things for a $300 blower door test. You could map out a whole slew of energy efficiency improvements that would save you money. So education still is a big hurdle.

And then last but not least, the Weatherization Program. It's a hugely successful government program. It reaches the most vulnerable. It saves almost, on average, $300 to those families a year. Those savings are cumulative.

So there's ways to either amplify that program and also ways to modernize that program so it could go deeper in terms of those energy savings. I think that would be tremendous as well.

The CHAIRMAN. Okay.

I am well over my time, but I see Mr. Conant is just itching to jump in here. So, if I may?

Mr. CONANT. Yup, thank you.

From the solar side, one of the biggest challenges we run up against in our work with low income West Virginians is that the biggest solar incentive in the country is the investment tax credit. Unfortunately, that is based on someone's income.

The CHAIRMAN. Right.

Mr. CONANT. So for anyone that is at the average West Virginian family income or below, they're not able to take that tax credit in one year.

The CHAIRMAN. Yes.

Mr. CONANT. It would take multiple years of dragging it out.

And so, particularly, when we get calls from retirees or the like, it's every other day we're getting a call from someone who lives in manufactured housing and has a $600 monthly electric bill, and we start talking with them. We just can't help them because this tax incentive does absolutely no good for them. Same thing on the nonprofit side.

So if I had my magic wand, I'd really focus in on how do we expand the eligibility of that tax credit, whether it's through making it refundable or some other mechanism to make sure that we're not only sending our incentive dollars toward higher income folks.

The CHAIRMAN. I appreciate you bringing that up. I think I want to talk about that a little bit more on the second round.

Senator Manchin.

Senator MANCHIN. Thank you, Madam Chairman.

I think to both Dans here, Mr. Simmons and Mr. Conant in West Virginia, when I was governor, we did an energy portfolio and with that we had net metering back. Since then, the legislature and the current governor have repealed or undermined those policies, making it very difficult on some of the things we were trying to accomplish.

At the federal level you are talking about the tax incentives and things that go with this. So for each of you, where do you see the best mix of policies? The best mix because, in our state being a heavy extraction state, there is a lot of things that are preventing us from moving forward. And I understand it, but you know, the market is the market. The market has got to move, and we are impeding that.

Where do you think the level for the deployment of renewable energy technologies is? And do you all, any of you all, see renewables ever being baseload? So whichever Dan wants to start first?

Dan? West Virginia Dan.

Mr. CONANT. One point of correction. Net metering was not repealed by the state. There was——

Senator MANCHIN. They tried to and they didn't. But let me tell you right now——

Mr. CONANT. There was an attempt.

Senator MANCHIN. ——the Public Service Commission is considering changes to states. I mean, as you know, they are right now considering those changes.

Mr. CONANT. Yeah. The current debate in the Public Service Commission is regarding the technology behind bidirectional meters——

Senator MANCHIN. Yes.

Mr. CONANT. ——and whether to require that.

Senator MANCHIN. Well, I think what they were saying, they always come back at me basically saying, you allow net metering back, who is going to pay the bill?

It is going to raise everybody else's bill. It was only at three percent, so we knew it wouldn't affect anybody's bill. We wanted to see if it would work. And we've had to fight just to keep it in there. And I am hoping you are able to. But I know they are making attempts at changing it. But anyway——

Mr. CONANT. I think one of the most powerful things we have going for us right now in terms of defending net metering at the state level is that we are expanding this beyond the well-to-do. It's not just a country club thing. It's a homeless shelter thing. It's a——

Senator MANCHIN. Well, they start speaking, thank God, that is what kept it from being repealed.

Mr. CONANT. Okay.

Senator MANCHIN. The policy, basically, it is affecting you all and you are just talking briefly about that, and I know that Senator Murkowski wanted to talk more about that too.

But the technology is renewable.

Mr. CONANT. As far as federal policies that can help us, even in states that have policy headwinds, I think so much of it comes back to the structures that are put in place, either for tax credits or also for federal loan and grant programs.

Senator MANCHIN. Yes.

Mr. CONANT. So, for instance, with USDA with the Rural Energy for America program, great program, covers, it can provide grants for up to 25 percent of the system cost for a business. But the limitations they put on there are extremely disfavorable against any project in a state that doesn't have power purchase agreements. And there are 25 states in the country that don't allow power purchase agreements that don't have a competitive marketplace. So through the restrictions that the USDA program development staff have put into place, they've really left out a large swath of the country.

Same thing with the IRS in how they've interpreted the investment tax credit rules. They've put lots of restrictions, once again, around requiring PPAs which just don't work in West Virginia. They don't work in Kentucky.

So I'd love to see just opening, the Federal Government opening up eligibility around those programs.

Senator MANCHIN. Well, I would like for all of us, I mean, especially those of us in the Senate here, basically in the next round of extenders, which is tax credits—I have always said in states like ours, who are very heavy extraction states, that as we transfer and the market transfers, those credits should be given under the condition that a majority of that investment, if you are going to take the credits, be used in states that have lost the energy jobs.

I mean, I have a coal miner that can build you the best solar power and the best wind power you have ever seen, if they had a chance. But the dollars, if the dollars don't force them to go there, I think, Mr. Simmons, it falls into your category there, if DOE would support something such as that, trying to make those dollars move into areas that we had a transition in energy market.

Mr. SIMMONS. Sure, I mean, Under Secretary Menezes was out in Appalachia last week talking about a new kind of ethane petrochemical hub that has potential there.

On the issue on policy for these technologies we're talking about today with renewable technologies, I haven't been focused too much on policy, but instead, really on technology, to drive down the cost, to continue driving down that cost curve and then integrating these technologies together so that you can actually get calls from, so that Dan can get calls from people living in manufactured housing who are thinking about solar panels. So that actually, kind of, makes sense for them.

So that's really what we're focused on is by having a low enough cost that really the policies don't matter as much. And that's—plus it makes my job easier to focus on technology.

Senator MANCHIN. Thank you, Madam Chairman.

The CHAIRMAN. Senator Hirono.

Senator HIRONO. Thank you, Madam Chair.

I recently visited Vietnam with Chair Murkowski and other Senators, and we heard about that country's rapidly growing demand for energy and worsening air quality.

I am glad that NREL—this is a question for Dr. Keller—that NREL has worked with the University of Hawaii's Hawaii Natural Energy Institute, to help Vietnam develop plans and standards to use more renewable power sources.

I expect you have followed the efforts of China to build coal plants in neighboring countries as part of its multi-billion-dollar Belt and Road infrastructure initiative which will worsen the impacts of climate change for people in the United States and everywhere and elsewhere in the world.

What more could NREL and Congress do to help countries in Asia direct their energy developments toward renewable, low-carbon sources?

Dr. Keller.

Dr. KELLER. Senator, thank you.

You bring up a very, very good topic because when you look at this historically, when you look at NREL, we are working with about 90 different countries, all over the place. And it always depends what country you're dealing with that the level of help is very different when you go into it. Some of the countries don't even have wind maps or solar maps. So where we can help them and show them how you can create some of the very basic maps to understanding what resources you have.

And then it all goes to the path to see how could they bring some of this technology in. Some of the countries don't have a grid system, so microgrid, very simple from our perspective. Solar panels with some small batteries will bring electricity to some of these houses.

So I would say what can we do to further steps into this direction, I think it's very important that we, as in our opinion, still as, we, as United States, as the world leader in some of these innovations, I think we should continue to work with some of these countries and show them a path how they could move this forward.

And if you go into some of those countries where their people want to have basic electricity, and I think they have a right to get this basic electricity, I would argue, building a full-scale grid might not always be the best solution. But so, if other countries come in and just selling their technology and we will not be present, then we're undermining our world leading capacity in this area.

Senator HIRONO. So you mentioned 90 different countries. Is NREL in Vietnam?

Dr. KELLER. I have to check if we are in Vietnam, but again, I said, we are in many different countries. I can get back to you and let you know, but I don't know if we are in Vietnam.

Senator HIRONO. This is for Secretary Simmons.

This year's budget for the Energy Efficiency and Renewable Energy Office, EERE, includes $353 million that Congress gave this entity, this office, last year but that DOE had not yet awarded at the time the budget was being put together late last year. The office, as Congress intended, has continued to allocate the funds to support energy efficiency and renewable energy research and development.

How much of the $353 million that Congress appropriated for this office now is obligated to fulfill its mission?

Mr. SIMMONS. I would have to get you that exact dollars.

One key thing is that that money was in the proposed request. There are, however, no restrictions that have been placed on anyone in the office not to obligate the money that was in that proposed rescission. I just want to be very clear that we are working hard to obligate all of the dollars previously appropriated.

Senator HIRONO. Do you have any sense—the reason the question is even brought up is that there is a sense that, maybe, that that much of that money has not even been obligated and may fall by the wayside.

So do you have any sense of how much of it—are we talking about the vast majority of that money already being obligated for its mission?

Mr. SIMMONS. Well.

Senator HIRONO. If you don't have a sense, that is okay, get back to us, please.

Mr. SIMMONS. I don't and I will happily respond, yes.

Senator HIRONO. Another question for Dr. Keller.

Hawaii is on the cutting edge of incorporating renewable power and energy storage. In April, I visited a solar and storage facility on Kauai Island which is the largest combined solar and storage facility in the world.

Did you know that? Of course, you did. Okay.

And there is a Kauai Island utility cooperative which is the only co-op, utility co-op, in Hawaii. It enables the co-op in Kauai to generate 50 percent of the Island's power from renewable sources. A similar project is under development for the Pacific Missile Range Facility on Kauai which is a military DoD facility and the company has developed a project, AES, distributed energy, was able to test a prototype of the project at the National Renewable Energy Laboratory in Colorado.

What is NREL doing to solve the challenge of bringing large amounts of renewable power and storage on to the power grid?

Dr. KELLER. So again, as you mentioned, we have this wonderful collaboration with organizations in Hawaii, where ease of the energy systems and the gracious facility helped Hawaii to, hey, you can really expand the amount of solar and the grid still is working well.

You could have brought up the big issue right now, in my opinion, for Hawaii, but for all the many other areas how do you then include storage to solar?

Right now, there is, the battery cost is dropping very quickly. I personally am not exactly convinced that lithium batteries will be the long-term future for large-scale storage on the grid. I think we will need the next generation of storage technologies.

We are working and again, also funded by EERE, what could be the next chemistry, will we move to more flow cell batteries, will it be different chemistry?

So there is a lot of research going on in this area to decrease the cost of storage because as soon as you will decrease this and then combine this with renewables, you open up a whole new field to go even to higher penetration.

Senator HIRONO. You know, because you need quite a lot of land, in my view, to have all that storage there. I know this storage facility on Kauai is lithium, right? So we need to move to improve.

Dr. KELLER. So, Hawaii is a very special case because for most of the, where you see an increase in renewables, I would argue that probably land is not the most stumbling factor in respect to storage.

But the cost of storage is the problem, and how do you scale it? And so, this is where we need more research and innovation.

Senator HIRONO. Thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Hirono.

Senator King.

Senator KING. Thank you, Madam Chairman.

As I was jotting my questions down, I realized that every one of them, just about, involved perverse incentives. I think one of the problems in this whole area is that our whole structure of how we pay for and obtain energy was created 100 years ago and the incentives go in the wrong direction.

The incentive is on the utility to build things. That is how they get paid. It is a rate of return. The more capital that you invest, the higher your rate of return for your shareholders. So we need to be thinking about how to maintain those businesses and a reasonable return for their investors, but at the same time, change the incentive so that there is an incentive to do renewables.

Here is an example. The payback on weatherization is enormous, I mean, particularly in northern climate states. And Mr. Grunau, here is an idea. In my experience, one of the barriers to weatherization is the cost, the capital cost, to the homeowner. And even though the return may be 100 percent or 40 percent or some very high number, they don't have the cash to make that investment.

I have heard of cases where the utilities themselves become the bank and lend the money to the homeowner to do the retrofit, and it is paid back through the utility bill. It relieves this whole financing question in its, sort of, neat way. Do you have some thoughts about that or how else can we incent these kinds of projects?

Mr. GRUNAU. Well, for one, I think that's a great idea. We had our previous Governor of Alaska, Governor Bill Walker, sign an on-bill financing technique like you're talking about. It hasn't yet been set up, but what people need is a mechanism to be able to afford these things, right, if they're going to afford it themselves? I'm just going to say, yeah, that's a great idea.

You know, another thing too is if we could—people don't know, people just don't know what they need to do to make their house more energy efficient or whatever. So, and we talked, and it goes back to the education piece.

Senator KING. Well, let me make a suggestion there.

Mr. GRUNAU. Sure.

Senator KING. We now have enormous capacity to process and utilize data cheaply in a house. The Prius effect, if you know what your house is using for energy and what different decisions you make and you can see it, the theory is that Prius drivers get about 10 percent additional mileage just because they can see what is happening on that little screen.

If if you hear about me hitting an abutment, it is because I was watching the screen and not the road.

[Laughter.]

But this would be, you know, a simple device, like a thermostat, only it would be data. Here is what you are using. Here is what you are using for heat. Here is what you are using for electricity. I commend that to you.

Another problem with incentives is the utility opposition to distributed energy, because if you put solar panels on your roof and don't use as much energy then the utility loses revenue. We have to figure out how to change those incentives.

Another one that we have not talked about today, I don't think, in many places now the cost of transmission and distribution exceeds the cost of the energy. And that is a significant cost driver in the whole energy picture.

Again, but the incentive on the utilities, generally, is to build more transmission because that is how you—and they are not bad people, they are just doing what the market tells them to do.

But we need more incentives for a more efficient use of the grid. Time-of-day pricing, so that you use power when it is cheap at night. You can flow more kilowatt-hours, for example, to charge a car which will lower the cost of distribution and transmission because you have more kilowatt-hours upon which to use that fixed base of the cost of the transmission. They don't have to build any new wires in order to do that.

So, Mr. Simmons, is that something that you guys are looking at? I mean, the grid is one of the most inefficient animals on earth. It is like a church built for Christmas and Easter and all the pews are empty in the middle of April.

Do you see what I mean? We built this capacity for the hottest day in August, and it has to be there, but most other days, and particularly in the middle of the night in the winter, you don't need all that capacity. So evening out the utilization of the grid would be a much more efficient use of that fixed cost asset.

Mr. SIMMONS. And this is also one of the things that I'm talking about when I talk about greater flexibility in the grid overall. As in, one of the ways to deal with flexible generation is to have more flexible consumption. As in, for buildings to be able to respond to, you know, to increases or, really, to respond to what the prices are on the grid.

Senator KING. The market signal, yes.

Mr. SIMMONS. And buildings need to have better communication technologies. It's also very helpful for those buildings to be more energy efficient overall so that the buildings are seen as a resource for the grid. But this is a real opportunity.

Senator KING. And electric cars might also be the same. I mean, it is a distributed storage capacity.

Mr. SIMMONS. Exactly. Over 70 percent of electricity is consumed in buildings and, at times of peak demand it's over 80 percent.

So there is a real opportunity, but we need better communication technologies as well as insulation sensors. And we are, I mean, that is a large percentage of the work that our Building Technology Office is currently doing.

Senator KING. Just two other quick suggestions.

Dr. Keller, enormous potential in offshore wind. Gigantic potential, higher capacity factor, higher efficiencies, fewer environmental

questions. That's got to be in our thoughts. I mean, on both coasts, we happen to be a country that has a lot of demand on our coasts.

And, of course, storage. Storage is the whole deal in terms of integration of renewables and I agree with you, I don't necessarily think lithium batteries are a long-term answer. But if we can crack economic storage, then solar, then there is no barrier to solar and wind.

And hydro, as Senator Heinrich said, can be used. If you have storage in hydro, that could be the battery. That is what Norway and Denmark are doing right now is swapping power back and forth. Wind in Denmark, stored hydro in Norway. So I hope that is high on your agenda.

Dr. KELLER. Senator King, I couldn't agree more with you, absolutely. And let me just throw something in there, how you described the grid, you made the perfect case for a lot of utilities looking into their business plans for the future.

So there's a lot of changes coming along. Very similar how you describe that there's a lot of new business opportunities just with how Dan described——

Senator KING. We have to provide them with an incentive to chase those instead of opposing them.

Dr. KELLER. Yeah, I think the interesting thing is, I don't know if it's a necessary incentive or if it's the way we structure some of our oversights on the grid. I think this will change over the next years, in my opinion.

Senator KING. Thank you.

Thank you, Madam Chair. Sorry I ran over.

The CHAIRMAN. No, no, thank you. It is good conversation.

Senator Manchin, you wanted to do a wrap-up comment here.

Senator MANCHIN. I am just going to wrap up with a comment, but I want to thank all of you. It has been extremely enlightening for us and very hopeful.

Both of us, myself and the Chairman here, are both coming from extraction states of Alaska and West Virginia. People have an impression that we don't want to move things forward or climate change is not real. On the contrary, it is real and we know it is real and we are seeing effects in all of our states—in West Virginia with horrific floodings that we have seen, disproportionate levels, and what you are seeing is melting of ice and rising sea levels.

So all these things we are talking about, but there are some people today and in discussions you are seeing where they want to take positions of eliminating certain sources.

We are more for innovation and not picking winners and losers in the market, but not putting impediments if winners and losers don't move forward in the market. And in some of our states, we have them as impediments. And also the Federal Government has not recognized that there is support that is needed if you want to have public buy-in, that you have to have a plan going forward. You cannot leave certain areas of this country behind.

The people have done the extraction, have mined the coal or did the drilling for the oil and the natural gas. As markets change, they have to have opportunities to still survive, and that has been so shortsighted.

I would hope that from the Department of Energy leading the charge here and basically giving input back into the White House, if you will, the Executive Branch, understanding how we can do this in a more balanced way.

But us, through our tax incentives and our extenders, picking winners and losers has not worked because the market is what the market is going to be and so people demand. And we are going to make sure we are providing those opportunities.

Thank you all, and we just really appreciate this exchange and I hope that we do more of it.

Thank you.

The CHAIRMAN. Thank you, Senator Manchin.

I had one more question and you just keyed that up very well, because we have talked a lot about those policies that will enhance greater efficiencies, greater integration of renewals. When I asked if there were certain things the Federal Government can do from a policy perspective, we talked about R&D, we talked about weatherization. There was mention of standards.

There really has not been much discussion about those policies that relate to tax incentives, those that get the investors involved or help move things around.

There is a tax extenders package that is under consideration now. I don't happen to sit on that committee, but some of those in the media are always asking me questions about well, what do you think about tax extenders and solar and wind? We have the ITC in the residential solar marketplace that is going to disappear completely in 2022.

Let's have a quick little discussion here from your perspective.

I mention in my opening statement that so many of these renewable technologies are really standing on their own now. I mentioned the contracts underway for solar in this country and what that means.

Are we beyond that time when wind and solar that have enjoyed the benefits of these tax credits for these many years, no longer need them? Remember, we had a deal, we were phasing things out, but now there is a lot of discussion about, well, we didn't really mean that phaseout.

I am curious to know from your perspective and we have the government side, we have the trade association side. And we have those that are kind of making it happen on the ground. What happens if these tax incentives go away, phase out? Do we need more?

I really appreciate what you have mentioned, Mr. Conant, about the impact to the non-profits, the limitations there, the limitations that we have when you cannot avail yourself of these tax credits because of your income.

So we have about five minutes here. Let's talk about this role that the Federal Government plays, good, bad or otherwise. And this is a jump all for you all. Mr. Hartke.

Dr. HARTKE. Well, I'll jump in first.

I think these tax incentives are invaluable. And I think, in the context——

The CHAIRMAN. Well, they have been invaluable. The question for us as policymakers is how long do you extend them? How long do you give them that advantage?

Dr. HARTKE. Right.

The CHAIRMAN. To use Senator Manchin's term, picking the winners and losers.

Dr. HARTKE. Exactly, no, exactly.

The CHAIRMAN. I didn't mean to cut you off there.

Dr. HARTKE. No, I was just about to get into that exact point because you're right, when has the market caught up?

And I think that when, at least on the energy efficiency side, when those incentives were first designed and created, we've seen, thanks to our good friends down at the other side of the dais here, some tremendous innovation.

So the question is in the context of the threat of climate change, which means that we need to move a lot faster. How do we get the best technologies available out into the market? And I think that there's, that's a tax incentive conversation and it's an innovation question.

We haven't talked much about the Administration and their, kind of, laser beam focus on early stage R&D. In my day it was RDD&D because demonstration and deployment were just as valuable. And as, on the tax incentive side, we know that that will increase deployment, that will increase adoption and therefore, that will bring down prices and make sure that these best available technologies are reaching more people. That, to me, is the government role and why they should intervene.

We know from the McKinsey report of 2009 that best available technologies often do sit on the shelf. They don't get out. They don't commercialize as easy as we think because of all these various market barriers, particularly in energy efficiency.

So tax incentives make a big, big difference. There's a DOE analysis that shows just on the 25-C home products tax incentive, again, it's expired, but if that were extended for 10 years it would save consumers, it would save these consumers $52 billion. And it would get, again, these best technologies out in the market in a time that we need the best available, as fast as possible.

The CHAIRMAN. Other comments?

Mr. Conant.

Mr. CONANT. I would add that we're seeing state-by-state, utility-by-utility, the price of solar and wind come down and down and get more competitive with fossil fuels.

However, that is on a state-by-state, utility-by-utility basis, where we saw it first in Hawaii and Massachusetts and California. But that doesn't mean that it has completely reached the Indianas and West Virginias of the world.

Phasing out the ITC and the PTC at the current, well, I can't really speak to the PTC, but as far as the ITC goes, phasing it out according to the current schedule would leave us with regional disparities that, just as far as where solar will make the most sense against the, within the current utility structure or public service commission structures. So I would be in favor of extending just to give us a little more time to make sure that solar is reaching everyone across the country and not just the coast.

The CHAIRMAN. Other comments?

Mr. Simmons, you are framing something there.

Mr. SIMMONS. It is a difficult—I do not know if the Administration has a position on the issue of the ITC and PTC, so that is, I don't want to touch that part.

These, the ITC and the PTC, definitely help the deployment of the resources that utilize them. I talked to the head of EDF Renewables last week who was, you know, wondering what is going to happen with the PTC for wind since they're one of the largest wind developers or wind owners in the United States and it would lead, in his opinion, to a reduction of wind deployment.

And but, the question that you ask, I think, is a very important question is when do we have that, when do we have a level playing field? And that one is one that I can't necessarily answer.

It's one where, at the Department of Energy, well in my office, what we're really focused on, you know, we aren't focused on beating up on fossil fuels. We're focused on driving down the cost of renewables and then letting the market take it from there. And so, we have, the Office of Energy Efficiency and Renewable Energy, I think, with the help of national labs and others, have had tremendous progress in that area in recent years.

Senator KING. Madam Chair, could I make a contribution on this question?

The CHAIRMAN. Absolutely and, before I yield to you, I just want to go back to the point that you made, Mr. Simmons, in your testimony several times. You talked about the area that we are limiting our self is in the integration. If we have the incentives that are there to build it, okay, that is fine, well and good, but then how do you get that integrated into the broader market?

Senator King.

Senator KING. I think it is important in having this discussion to realize that it is not a level playing field and that we are talking about incentives that have been added relatively recently for wind and solar, but there are also embedded in the tax code, incentives for oil and gas——

The CHAIRMAN. Other energy——

Senator KING. ——and extraction going back 100 years, so if we want to, I have always said, yes, let's level the playing field, make it level. Let everybody compete.

But if you have tax incentives on one side and you take away on the other side, that is not a level playing field. So you are asking the right question, but in analyzing it, we really need data on the economic impact of the things like the oil depletion allowance and other embedded provisions in the tax code that have been there forever and are not as, sort of, obvious, as things like the PTC that are of fairly recent origin.

Thank you.

The CHAIRMAN. Fortunately, we are not the Finance Committee so that we don't, we are not the committee——

Senator KING. Through some oversight.

[Laughter.]

The CHAIRMAN. But it is part of the discussion because we can focus on the great technologies that are out there, what we are doing within R&D. But again, part of what we are trying to do is get this out there on the ground and how does our conversation then knit together with what Finance and the other committees are

doing as we really try to gain the advantages that these efficiencies can deliver to us.

I do think that this is an area where we either fail to understand and appreciate or to see the benefits that come from efficiency. We think that it is not enough to really make a difference, and yet this is where the United States really is shining.

I was interested in listening to Senator Hirono's question coming from our trip to Vietnam there and the discussion that was had there about what the United States has done to so dramatically reduce our energy consumption driven by efficiencies and what more we can do in leading by example with that. Again, great opportunities are clearly out there.

I do think that we are wholly deficient when it comes to the education piece of this. It has been a long time since I was a den mother in a scout troop, but at that time that was the only place I ever saw a real focused effort in something with our kids, focused on conservation. You could get your conservation merit badge. And I think we are probably doing a little bit better now. But our kids are probably more aware of what can be done to conserve and to be more efficient than even we are. And so, how we educate all of us and then share this education beyond just the United States here, this is something where I think we have some opportunities, but we have not done a very good job in that area. So we will be working on that. I am going to be working on the temperature.

I want to thank you all for your comments here today. I think you have given the Committee some good food for thought.

Mr. Conant, I just really appreciate hearing what you have done, a small group of probably young people who want to make a difference and kind of, opening some eyes about what the possibilities are, not waiting for the government, either the federal or the state, to help you out, but figuring out how to do it on your own and really setting that model.

I want to acknowledge the work of the Cold Climate Housing Research Center because what you do up there demonstrates the realm of the possible and for all of my visitors that come to Alaska, it is almost an obligatory stop on the tour when you are in Fairbanks to see what is going on there. But knowing the difference that we are making to families, working in conjunction with our national labs.

And I appreciate the role that the labs play, and I would hope that we can be doing more pairing with our national labs with entities just like Cold Climate Housing Research Center and taking the genius that is on the ground and utilizing the genius of the men and women in our national labs and working with DOE I think we have a great opportunity.

Dr. Keller, I don't know if you got over to the Cold Climate Housing Research Center when you were in Fairbanks, but if you haven't, you should talk to some of your other lab directors that were there. It was a pretty cool thing.

Dan, I think you have been there, haven't you?

Mr. SIMMONS. I have not yet, unfortunately.

The CHAIRMAN. We can make arrangements for that. We will——

[Laughter.]

Senator KING. Madam Chair, I hope that the Center will share what they are learning because we have a very old housing stock in Maine, a very tough northern climate. So, to the extent you are learning projects, what works, best practices. We do a lot in weatherization, but there are always things to be learned and if you have ideas that can be passed along, we would love to have them.

The CHAIRMAN. I am just going to talk out loud here about an idea, but since you and I are the co-chairs of the Arctic Caucus, it might be a good brown bag lunch to have a presentation on housing in colder places—it does not necessarily need to be Arctic. I mean, right now, in Colorado, it is colder than it is back home. But just to focus on that because it is not only what Cold Climate Housing is doing but we have other research from other Arctic countries that, I think, would be very, very helpful in focusing on some of the efficiencies and the innovation, if you would be up for that?

Senator KING. I'm in.

The CHAIRMAN. Okay.

Mr. GRUNAU. We're in, absolutely.

The CHAIRMAN. Alright, we have a lunch date. There we go.

Alright, gentlemen, thank you so much. We appreciate it.

With that, the Committee stands adjourned.

[Whereupon, at 12:14 p.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
Hearing: *Opportunities to Advance Renewable Energy and Energy Efficiency Efforts in the United States*
Questions for the Record Submitted to the Honorable Daniel R. Simmons

May 21, 2019

QUESTIONS FROM CHAIRMAN LISA MURKOWSKI

Q1. Recently a $100 million joint research effort between ExxonMobil and two National Labs was announced. Its purpose is increasing energy efficiency and reducing emissions from fossil fuels production.

Q1a. In general, how do you view the relationship among Department of Energy, the National Labs, and the private sector on energy efficiency and renewable energy efforts?

A1a. Public-private partnerships, like the ExxonMobil and National Lab one mentioned, help ensure a more efficient, cleaner, and prosperous future for energy technologies. The Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works with industry, academia, National Laboratories, and other partners to create technology-specific roadmaps, which focus DOE resources on the most fundamental technology challenges. This collaboration between DOE, our national labs, and private industry delivers impactful knowledge and technology innovations that transform energy technologies, systems, and markets.

In fiscal year 2020, National Laboratories will be encouraged to form Cooperative Research and Development Agreements (CRADAs) with industry, utilize Agreements for Commercializing Technology (ACT), enter into Strategic Partnership Projects (also known as Work for Others) and conduct User Facility calls for university and industry proposals (e.g., Energy Systems Integration Facility at National Renewable Energy Laboratory) to further leverage National Laboratory expertise and infrastructure.

Q1b. Are there areas in that dynamic where Congress can be immediately helpful?

A1b. The Department views Congress as a key partner in striving towards an affordable, reliable and resilient energy future. We look forward to a continuing dialogue with Congress about ongoing energy efficiency and renewable energy activities and emerging opportunities.

Q2. What is your perspective on the role the Department of Energy's Appliance and Equipment Standards Program plays in the overall energy efficiency landscape?

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A2. The Appliance Standards Program (ASP) is one of many programs that EERE spearheads in the energy efficiency landscape. Advances in energy efficiency have been driven over time by a combination of market-driven efficiency improvements, which DOE facilitates via early-stage research, and federal appliance standards. In addition to the ASP, EERE's Building Technologies Office is engaged in research to drive innovation in energy efficiency for building components and to reduce the cost of energy efficient products to make them accessible to more households.

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QUESTIONS FROM RANKING MEMBER JOE MANCHIN III

Q1. I understand DOE's analysis identifies sites in West Virginia with hydropower potential including several non-powered dams in West Virginia. What are the barriers to making hydropower cost effective in states like West Virginia?

A1. The cost effectiveness of hydropower development in the U.S. can be inhibited by these factors:

1. **An uncertain and lengthy regulatory authorization process** – The length of the FERC licensing process (including application preparation) varies greatly from about 5-7 years (with some projects taking over 10 years), depending on the complexity of the environmental issues. While FERC is the federal agency charged with issuing federal licenses under the Federal Power Act, proposed hydroelectric projects are subjected to approvals from other state and federal agencies under separate statutes such as the Clean Water Act, Endangered Species Act, and National Historic Preservation Act. As a result, federal and state approvals are subject to a variety of processing schedules outside of FERC's authority. This disparate approval process contributes to process uncertainty.

2. **High capital costs associated with construction or modification of civil works** - Because of the site-specific nature of hydropower projects, capital costs associated with new project construction at greenfield sites or non-powered dams can exceed 50%. In-river construction times can be constrained by hydrological variation. Modification of existing dams may be constrained by existing uses and costs associated with improving environmental and safety standards.

3. **Rising operations and maintenance costs -** Another limiting factor associated with hydropower development is recent trends in operation and maintenance (O&M) costs, which have been rising at rates higher than inflation for the past decade for all but the largest hydropower plants. Adjusted O&M costs have increased over 20% since 2007, whereas the consumer price index has increased only 16% over the same period. Some of the reasons for

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this include: aging workforce, declining quality assurance/control on newly purchased equipment, and compliance with increasingly stringent regulatory requirements.

4. **Limited financing opportunities** – The uncertainty associated with factors 1 and 2 above contribute to limited financing opportunities for new hydropower projects. In addition, power purchase agreements typically have terms well less than the 50+ year operational life of hydropower assets. This lack of guaranteed revenue over the life of the project can limit the available financing opportunities.

Q2. Any specific reasons sites in West Virginia haven't been developed?

A2. As a research and development organization, DOE is not involved in the development of projects. DOE does not have insight specific to state-level development of hydropower resources.

Q3. What technologies and planning methods exist to upgrade hydropower facilities while protecting river health and wildlife, including fish stocks?

A3. DOE's Water Power Technologies Office (WPTO) is committed to lowering the cost of hydropower deployment while significantly reducing the environmental footprint of new and existing technologies as part of its HydroNEXT initiative. Cost-effective fish passage technologies will assist hydropower owners and operators in meeting rigorous environmental permitting requirements and bring additional hydropower online faster. These technologies provide information about timing of fish migrations, the quantities of fish, and the types of fish that utilize fish passage facilities and are essential to advance real-time monitoring efforts and optimized fish passage operations.

Enabling safe turbine passage through biologically-informed turbine designs will improve individual fish survival, thereby reducing impacts on fish populations and aquatic ecosystems, while simultaneously increasing power production and flexibility as new and rehabilitated turbines come online. The Biologically-Based Design and Evaluation of Hydropower Turbines (BioDE) project is designed to provide information that will support biologically-based design, operation,

and evaluation of hydropower turbines. Environmentally safe turbines allow for cost savings and revenue enhancement because turbines can be operated with maximum flexibility, reliability, and resiliency without constraints for fish passage.

Q4. What is DOE doing to reduce these barriers and work with industry to get more investment?

A4. WPTO invests in early-stage research to accelerate development of innovative water power technologies while ensuring that long-term sustainability and environmental issues are addressed. The challenges identified in Question #1 have inhibited development of hydropower resources. If these challenges are addressed, there are significant opportunities to increase hydropower capacity in the UnitedStates. The 2016 Hydropower Vision Report identified that approximately 23 GW of new hydropower development could be possible at greenfield sites and non-powered dams if technologies that balance efficiency, economics, and environmental sustainability are developed.

Hydropower is a renewable resource capable of offering a host of flexibility services such as ramping, frequency response, and black start that can support grid reliability. However, the specific design and operational attributes that may prove most useful within the future power system are not well understood. This uncertainty can result in plant and fleet-wide inefficiencies in how existing power and ancillary services are evaluated, procured, and compensated. Quantifying the value of hydropower and pumped storage hydropower (PSH) within future power systems will enable more efficient planning and operations and will provide needed inferences into how future research and development (R&D) should be directed. Given these challenges and opportunities, WPTO has developed a research initiative focused on understanding and enabling utilization of the full potential of hydropower and PSH to contribute to electric system reliability and resilience, now and into the future. The HydroWIRES (Water Innovation for a Resilient Electricity System) portfolio is organized into four interrelated research areas. Structurally, the first two research areas establish a critical, baseline understanding of what range of services may be most valuable for the future grid (depending on different ways it may evolve), together with what services hydropower can (and cannot) contribute. Defining the interrelated structure of those two research spaces

provides needed insights into which services and attributes the hydropower fleet can and should be prioritizing. The third research area establishes a bridge between the previous research spaces in defining how findings can be operationalized—given better information on what grid services or flexibility the future grid may need, and what grid services hydropower can provide, research area 3 illustrates how the fleet can most aptly take advantage of available opportunities, in terms of both operations and planning. The final research area integrates the findings from the previous three spaces to inform technology development and innovation that can expand hydropower and pumped storage technologies abilities to provide valuable grid services.

Additionally, WPTO is investing in the Integrated Hydropower Storage Systems Project to explore the potential and develop the necessary tools to integrate energy storage systems with hydropower plants. These integrated facilities can operate more flexibly—providing greater value to the grid—while also increasing participation in ancillary service markets.

To tackle high capital costs for in-river construction, WPTO launched the Standard Modular Hydropower (SMH) project in FY16 as a completely new approach to designing hydropower facilities. SMH can deliver the benefits of hydropower at lower cost and with greater environmental benefits by leveraging standardized and modular component designs that are more easily and cheaply manufactured. In tandem, SMH shifts the design philosophy from custom-designing every facility to extract the greatest amount of energy possible and then mitigating impacts, to focus on first sustaining the important hydrologic, hydraulic, geomorphic, physiochemical, and ecologic processes that occur in streams and watersheds. SMH technologies can also be leveraged to provide additional co-benefits beyond energy generation, such as water quality enhancement, invasive species control, hydrologic restoration, and recreation opportunities. In FY18 and FY19, WPTO released competitive solicitations to fund SMH technologies as part of this effort. The program is also planning another competitive solicitation for SMH pertaining to non-powered dams as part of the President's FY 2020 Budget Request.

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WPTO has also launched the Furthering Advancements to Shorten Time (FAST) Commissioning for Pumped-Storage Hydropower (PSH) Prize, which is designed to attract ideas to reduce the time, cost, and risk required to commission PSH projects. The U.S. PSH fleet accounts for the majority (95%) of total utility-scale electricity storage in the country, provides large-scale electrical system reserve capacity, contributes to grid reliability, and supports electricity supply-demand balancing by offering quick response capabilities and operational flexibility. While PSH is being aggressively built around the world, new PSH project development in the United States has stalled in recent decades because of low competing natural gas prices, significant upfront capital costs, and long commissioning times. PSH development timelines can last for a decade or more. The FAST Commissioning Prize is a first-of-its-kind initiative and is structured to support innovative PSH ideas, new layouts, creative construction management, improved construction equipment, application of advanced manufacturing, or standardization of equipment.

Q5. I want to be sure the DOE is focused on pushing energy technologies that will create jobs in all communities - including those in states like mine.

A5. Please see response to question 7 below.

Q6. What is DOE doing to support workforce development efforts in the efficiency and renewable industries?

A6. EERE has a number of ongoing workforce efforts across our programs, focusing in different technology areas. Some examples include:

- The Advanced Manufacturing Office (AMO) supports a number of Industrial Assessment Centers around the country, which conduct energy efficiency, productivity improvement, industrial information technology and waste reduction assessments for small- and medium-sized manufacturers. The IACs utilize university-based engineering faculty and engineering students to do the assessments and teach the students hands-on skills and knowledge of industrial systems and practices. The Solar Decathlon is one of DOE's highest profile competitions for college students. It comprises 10 contests, challenging student teams to design and build highly efficient and innovative buildings powered by

renewable energy. One of the primary goals of the competition is to inspire next-generation building professionals to apply the latest building science innovations in new and existing homes and commercial buildings.

- In October 2018, EERE announced nearly $13 million for solar workforce initiatives as part of a larger funding opportunity announcement. These projects will support training and curriculum development for students and professionals at all stages of their careers, and participants will combine classroom learning with hands-on experiences in both the lab and real world.

- EERE is also working with stakeholders to train and inform over 36,000 first responders and code officials on the use and safety of hydrogen and fuel cell technologies, particularly reaching out to industry and veterans to identify key skillsets required to enter the hydrogen and fuel cells workforce.

- The Vehicle Technologies Office (VTO) invests in both research to develop cleaner, safer, more affordable vehicles and education to ensure a strong workforce that can develop, build, repair, and respond to these vehicles. VTO helps to develop the nation's workforce through student competitions and partnerships with educational organizations to provide training for mechanics, first responders, code officials, and electricians on advanced and alternative fuel vehicle technologies.

- DOE's Weatherization Assistance Program (WAP) developed and maintains a foundational workforce training and certification program to ensure quality work is performed in WAP residential weatherization retrofits for low-income homes. WAP provides accreditation and support for 21 training centers involved in training weatherization crews, a number of which operate out of universities and other organizations. Among them, these centers offer a combined 65 accredited training programs.

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Q7. What is the Department's plan to ensure that rural states like West Virginia are not left behind when establishing energy workforce training?

A7. Many of EERE's existing workforce activities have national application and provide opportunities for both rural and urban communities. For example, West Virginia University was chosen as one of 13 universities to compete in DOE's latest Advanced Vehicle Technology Competition (AVTC): EcoCAR Mobility Challenge. AVTCs provide a challenging, real-world training ground for North America's future engineers and automotive leaders and accelerate the development and demonstration of technologies of interest to the U.S. Department of Energy and the automotive industry. Featuring opportunities for graduate and undergraduate students from a variety of disciplines including engineering, business, program management and communications, these competitions challenge students beyond the traditional classroom environment. More than 16,500 students from 91 educational institutions across North America have participated.

Q8. As I understand it, a major challenge to greater manufacturing and adoption of renewable energy technologies is access to critical minerals. How is lack of a stable supply of critical minerals impacting our ability to increase renewable generation?

A8. There are over 500 factories across 42 states that manufacture wind turbine components. However, the U.S. lacks the domestic capacity to manufacture rare earth neodymium-iron-born permanent magnets, a key component that enables more efficient generation. Rare earths dysprosium and neodymium experienced price volatility in the earlier part of this decade. This contributed to domestic Original Equipment Manufacturer's (OEMs) opting for geared, doubly-fed induction generators as opposed to direct-drive wind turbines that use rare earth permanent magnet generators. This was somewhat limiting as direct-drive wind turbines are preferred for offshore and larger generation capacity wind turbines. As prices stabilized, domestic wind turbine manufacturers have recently been returning to rare earth neodymium-iron-boron magnets. The first offshore wind farm was built in the U.S. in 2016 off the coast of Rhode Island, which consists of five direct-drive wind turbines, with rare earth permanent magnet generators, rated at six megawatts each.

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Solar photovoltaic (PV) global installed capacity has quadrupled from 70 to 291 gigawatts from 2011 to 2016, with much of this growth in the United States. Since 2011, the market share for crystalline silicon solar PV, which is not reliant on critical minerals, increased from 86 to 94 percent of the global solar PV module sales. Because cadmium telluride (CdTe) and copper-indium-gallium-selenide (CIGS) thin film solar PV have a modest market share, the supply situation of critical minerals, such as gallium, are unlikely to impact our ability to increase solar PV generation.

Q9. What sector – wind, solar, battery storage -- is most vulnerable to a shortage of minerals in its supply chain?

A9. The Department of Energy assesses materials criticality based on importance to energy and potential for supply risk for a range of energy technologies. In the most recent assessment conducted by the Department's Office of Policy, the following materials were assessed to be critical or near critical in the medium-term (2020 to 2030):

- Critical:
  - Dysprosium and neodymium – used in permanent magnets for a range of applications including electric machines for electric vehicles and wind turbine generators.
  - Gallium – used to manufacture LEDs.
  - Cobalt and lithium – both used in the manufacturing of electrodes in lithium-ion batteries.
  - Rhodium – a platinum group metal. The leading use of platinum group metals is catalytic converters.
  - Magnesium metal – primarily used for casting in the automotive industry for vehicle light weighting.
- Near critical:
  - Palladium – a platinum group metal. The leading use of platinum group metals is catalytic converters.

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In 2018, the U.S. net-import reliance as a percentage of consumption was: 100% for rare earths including dysprosium and neodymium; 100% for gallium; 61% for cobalt; >50% for lithium; <25% for magnesium; and 33% for palladium. Net-import reliance was not reported for rhodium, which was reported as part of the platinum group metals.[1]

Wind - The United States lacks the domestic capacity to manufacture rare earth neodymium-iron-born permanent magnets, a key component that enables more efficient generation in wind turbines. Direct drive wind turbines use about 600 kilograms of rare earth magnets per megawatt of capacity. Hybrid designs that employ a single-stage gearbox with a smaller permanent magnet generator reduce the weight of the rare earth magnet to 200 kilograms per megawatt capacity.

Battery Storage – Lithium-ion batteries dominate the market for electric vehicles and grid energy storage. Cobalt and lithium are used in the production of lithium-ion battery electrodes, with material intensity varying depending on the chemistry. The Office of Energy Efficiency and Renewable Energy (EERE)'s Vehicle Technologies Office (VTO) funded research and development (R&D) at Argonne National Laboratory that has contributed to commercialization of electric vehicle batteries that use chemistries with less cobalt – reduced from 33% to 10-15% by weight, with a goal of less than 5%. In 2018, EERE announced over $50 million of laboratory, university, and industry research projects focused on significantly reducing the amount of cobalt in lithium-ion batteries or eliminating the need for cobalt altogether, while meeting the performance and life requirements for electric vehicles.

Electric vehicle (EV) sales are expected to drive the global demand of cobalt and lithium. The Department has projected that EV sales in the United States may reach 58 million by 2030 in a high-deployment scenario and 7.7 million in a low-deployment scenario. In high materials intensity cases for grid storage, lithium-ion batteries can contain up to 1,495 tonnes of cobalt and 641 tonnes of lithium per gigawatt capacity. R&D may reduce these material intensities to 0 tonnes of cobalt and 506 tonnes of lithium per gigawatt capacity.

[1] USGS Mineral Commodity Summaries 2019. https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

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Solar – Since 2011, the market share for crystalline silicon solar PV, which is not reliant on critical minerals, increased from 86 to 94 percent of the global solar PV module sales. Thin film solar PV has a modest market share of 3 to 10 percent for CdTe and 2 to 5 percent for CIGS. In high material intensity cases, gallium content in CIGS thin film solar PV is 7.5 tonnes per gigawatt capacity by weight. Similarly, indium is 23 tonnes per gigawatt capacity by weight. In CdTe thin film solar PV, tellurium is 69 tonnes per gigawatt capacity. Reductions in thin film thickness could result in reductions in material intensities of 73 percent on average.

Q10. What resiliency measures is the government and the industry undertaking to prepare for potential disruptions?

A10. The President issued Executive Order 13817[2], *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*, on December 20, 2017, to ensure secure and reliable supplies of critical minerals. The Department of Energy's approach to mitigate risk is in alignment with the President's Executive Order.

Within the Department, R&D investments are coordinated among the program offices agency-wide around three pillars to address supply chain disruption risks: (1) diversifying supply of critical materials – including increasing domestic production, (2) developing substitutes, and (3) driving recycling, reuse, and more efficient use of critical materials.

Office of Energy Efficiency and Renewable Energy (EERE)

Critical Materials Institute (CMI), an Energy Innovation Hub currently managed by the Advanced Manufacturing Office (AMO), is a consortium of U.S. National Laboratories, universities, and companies. Technologies developed are linked to industrial needs and enabled with fundamental research and cross-cutting analysis. While Congressional report language has continued to insist upon funding the CMI, the FY2020 Budget favors a transition away from the hub model because

[2] https://www.federalregister.gov/documents/2017/12/26/2017-27899/a-federal-strategy-to-ensure-secure-and-reliable-supplies-of-critical-minerals

the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities.

Lithium Battery Recycling – Vehicle Technologies Office (VTO)'s ReCell Center funds research for current and future battery chemistries, including recycling, recovery materials, cathode-to-cathode recovery, and reuse of recycled materials. The VTO and AMO jointly launched the Lithium-Ion Battery Recycling Prize to incent cost-effective, disruptive solutions for 90% recycling of spent lithium-ion batteries.

Critical materials extraction activities from geothermal brines are coordinated between Geothermal Technologies Office (GTO) and AMO. Development of seawater mining is funded by Water Power Technologies Office (WPTO).

Office of Electricity is working on grid-scale battery storage technologies that use domestically sourced earth-abundant materials.

Office of Fossil Energy, National Energy Technology Laboratory (NETL)'s Feasibility of Recovery Rare Earth Elements Program, is currently focused on developing technologies for the recovery of rare earth elements (REE) and critical materials from coal and coal-based resources.

Office of International Affairs is currently focused on countering attempts to control or distort the critical mineral markets.

Office of Science drives fundamental science to advance our understanding of critical materials down to the atomic scale, leveraging novel synthesis techniques and advanced computational and modeling capabilities. This research includes identifying replacements for rare earths in electronic and magnetic applications and alternatives to materials such as lithium and cobalt in batteries, and platinum in catalytic reactions.

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Office of Policy has led several studies assessing material criticality across energy technologies and potential for supply risk, and vulnerabilities related to market dynamics and volatility across supply chain stages—from mining to final product production and demand.

Advanced Research Projects Agency-Energy (ARPA-E) previously funded the Rare Earth Alternatives in Critical Technologies (REACT) program, which has fed into current activities across the Department, such as the EERE's Wind Energy Technologies Office (WETO) research into alternative motor and generator topologies that do not require rare earth permanent magnets.

The Department also coordinates with other federal agencies, such as the Department of Defense, Department of Commerce, and Department of the Interior, through National Science and Technology Council (NSTC) Subcommittee on Critical Minerals. The Department has been a co-chair of the Subcommittee since 2013 and continues to provide leadership among the federal agencies to address critical minerals across the entire supply chain. These efforts have contributed to the interagency response to the Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*, which was published by the Department of Commerce on June 4, 2019.[3]

Industry is actively engaged in addressing critical materials challenges in the supply chain. For example, Toyota has developed magnets that use half as much neodymium and eliminate the use of dysprosium and terbium.[4] The Department also partners with industry to address these challenges. Commercial lithium-ion batteries for electric vehicles have chemistries that use less cobalt – reduced from 33% to 10-15% by weight. This technology was developed from the Department's investments in R&D at Argonne National Laboratory.

[3] U.S. Department of Commerce. https://www.commerce.gov/news/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals
[4] https://www.autonews.com/article/20180220/COPY01/302209964/toyota-readies-cheaper-ev-motors-by-halving-rare-earth-metal-use

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QUESTION FROM MAZIE K. HIRONO

Q1. The President's budget request for FY2020 for the Department of Energy's Energy Efficiency and Renewable Energy Office (EERE) includes $353 million that Congress appropriated to EERE for FY2019, but that DOE had not yet awarded at the time the budget was being put together, presumably in the latter part of 2018. The EERE, as Congress intended, has continued to allocate funds to support energy efficiency and renewable energy research and development. How much of the money that Congress appropriated to EERE in FY2017, FY2018, and FY2019 has now been obligated by EERE?

A1. The offset of $353 million was proposed as a combination of prior year balances from 2005 – 2018. The initial sources of the offset were offered as a snapshot in time as of December 2018. The amount of available balances and office distribution changes regularly as EERE continues to award our FOAs. EERE did not place any of the funds on reserve and continues to execute them in accordance with appropriations law. As of the end of May 2019, EERE obligated $222 million of the $656 million in prior year funds carried forward on October 1, recovered $41.6 million from prior year unpaid obligations, and received $58 million in unobligated balances previously transferred for biofuels refinery demonstrations under the Defense Production Act.

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Questions from Chairman Lisa Murkowski

Question 1: Recently a $100 million joint research effort between ExxonMobil and two National Labs was announced. Its purpose is increasing energy efficiency and reducing emissions from fossil fuels production.

- *In general, how do you view the relationship among Department of Energy, the National Labs, and the private sector on energy efficiency and renewable energy efforts?*

The relationship between the Department of Energy, the national laboratories, and the private sector is strong and expanding. The national laboratories are tremendous assets for the nation. Coupling the R&D capabilities of the laboratories with the ability to scale innovation for market impact by industry is critical to achieving U.S. energy goals. Speaking for NREL, partnerships with businesses small and large is part of the bedrock for how we preform our work. We conduct rigorous outreach and analysis with energy-related corporations to understand their longer-term needs before we even set a course for R&D. On the other end of the spectrum, we engage across the U.S. energy industry to identify manufacturing and deployment limitations that the science capabilities of a national laboratory may be able to resolve. This makes advanced-energy technologies more economic and efficient, and helps boost U.S. job creation and competitiveness in the process. NREL has been doing this for its entire 42-year history and we are redoubling our efforts to address the energy transformation challenges for the coming decades.

- *Are there areas in that dynamic where congress can be immediately helpful?*

Congress can continue to support regulatory reforms that enable the Department and the national laboratories to partner with companies to conduct collaborative pre-competitive research or engage in technology maturation and commercialization efforts. Reforms that reduce process burdens, including reducing levels of approval, enable moving at the speed of business, i.e., taking actions consistent with normal business cadence – weeks not months. Agile processes, that offer flexible terms that are familiar to the commercial sector facilitate reaching agreement. Assistance to small businesses to navigate what can seem like daunting, bureaucratic processes could also make a difference.

In addition, Congress can support policies and funding to catalyze new and innovative partnership models and the infrastructure needed to support effective collaborations between the national labs and industry. For instance, national laboratories have used and are continuing to explore financing options for infrastructure that will attract partners and collaborators (third party, etc.). Specifically, NREL is exploring creating a partnering facility – the Energy Technology Transition Accelerator (ETTA) - on or near the NREL campus. This facility would provide the capabilities to support the growing number of commercial partners interested in co-locating near the laboratory for the purpose of

collaborating on research and development that leverages the knowledge and knowhow of the partner and the lab. It would support both small and large businesses who come for short durations to access technical assistance to mature and validate the performance of their technologies. And, it will enable delivery of entrepreneurship programs both to small businesses and to lab staff across the lab system who are seeking to commercialize their inventions. The facility would be the anchor tenant in what is envisioned for developing a larger clean energy science and technology ecosystem around the laboratory through the support of both the State of Colorado and Jefferson County. This facility will amplify partnerships with industry that are essential to sustaining American leadership in science and technology and to accelerating innovations from lab concept to market impact.

Question 2: In your testimony, you mention Perovskites and concentrating solar power as opportunities for solar power innovation. Where should we focus research and development efforts on solar to maximize the odds of a strong domestic solar future?

To be most effective, a solar R&D effort in the years to come must be multi-faceted. It must push forward promising technologies such as perovskites but also include work on other thin-film photovoltaic (PV) materials, as well as the development of an array of innovative, interconnected technologies that will allow solar power to be optimally and affordably integrated into our overall energy systems.

Fundamental science will play a role in realizing all our goals for solar power. This will include cost reductions and increases in PV conversion efficiency, as well as improvements for a range of power electronics, energy storage, and grid integration technologies. Science will also help us continue to resolve impediments in existing manufacturing processes through advances in materials synthesis and processing, which will lead to additional cost reductions and greatly increased production rates. Essential areas of research will be materials discovery, advanced materials processing, semiconductor physics and chemistry, and interfacial science, as well as the science of PV reliability at the cell and module level. And today, computational sciences developments are an ever-snowballing force in successful solar R&D, especially when linked with experimental science.

Perovskite solar cells have leapt to world-record efficiencies more rapidly than any other PV technology in history. This materials system, with its fundamentally unique properties and processing possibilities, has demonstrated promise for applications not only in PV, but also in solid-state lighting, advanced radiation detection, and quantum information science. It is the dual promise of high performance and low capital-cost manufacturability that makes perovskite PV unique in its potential to rapidly scale to meet energy supply needs and to create a U.S.-based manufacturing capability distinct from silicon PV. But foundational research must increase to ensure the technology is reliable and safe, and that scalability is demonstrated. The United States is leading in many areas of this science; however, other countries are investing heavily (e.g., China, U.K., Korea, Japan, and Switzerland). There is a significant, albeit time-sensitive,

opportunity for a consortium of national laboratories, universities, early-stage companies and U.S. manufacturers to come together with substantial federal funding to ensure the United States retains science leadership in this area and catalyzes a resurgence of U.S. PV manufacturing.

To meet the full potential of solar energy, we must also expand R&D for the next generation of viable concentrating solar power production systems that, in addition to electricity generation, also offer the added benefit of thermal storage. DOE's recently developed Generation 3 Concentrated Solar Power Systems Roadmap provides a compelling and impactful research and demonstration plan to achieve nearly 24-hour solar generation through the use of concentrated solar plus thermal storage. The roadmap—developed in close partnership with industry, academia, and other national laboratories—identifies the R&D challenges along three pathways: molten-salt, solid-particle, and gas-phase receivers. It is being used to guide DOE SETO CSP R&D decisions.

Other uses that could benefit from research advances in thermal storage materials and system designs are direct industrial process heat loads, desalination thermal loads, and large-scale thermal storage solutions for the grid.

As solar penetration levels rise, the issue of curtailment will negatively impact the economic potential for solar, creating a strong need to couple solar with storage. Long-term storage is also an issue for solar as generation can greatly exceed loads in the spring and fall seasons. As described in my testimony, we must also invest in Solar-to-X, which involves converting solar energy or solar electricity into chemical energy in the form of hydrogen, fuels, or other chemical storage media such as ammonia. Additional investments in solar fuels, advanced electrolysis, and solar thermal fuel production could provide cost-effective, efficient energy storage to complement battery storage. Such investments could also help drive a resurgence in U.S. industry and manufacturing, along with the attendant economic and job-creation benefits. Europe and others are investing heavily in advanced electrolysis through Power-to-X initiatives.

Solar energy research at NREL, universities, and other institutions has helped drive down the cost of solar technologies more than 90%, which has enabled market expansion and the creation of a burgeoning U.S. solar industry. Continued research investments will provide the foundation for next-generation solar technologies, which will create new U.S. jobs and solidify our nation's leadership in the most critical technologies for decades to come.

(For a more detailed examination of solar energy research needs, see my earlier Congressional testimony on this subject: https://science.house.gov/imo/media/doc/Keller%20Testimony.pdf.)

Question 3: You played an important role in last year's National Lab Day in Fairbanks, Alaska.

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- *Can you describe any partnerships, ideas, or other proposals that have evolved as a result of National Lab Day?*

  The benefits of Alaska National Lab Day and other direct dialog with Alaskan organizations have been manifest. Examples of collaborative efforts include:

  - **Advanced system integration, control, and cyber security**: The DOE Wind Technologies Development Office has initiated the Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad to facilitate the development of wind energy in isolated and weak power grids, which is very applicable to Alaska. Current work focuses on development of new integrated concepts that could receive further testing and pilot deployment in Alaska in collaboration with Alaskan companies and research organizations.

  - **Technology innovation**: Alaska National Lab Day identified a number of energy-related research challenges that have direct impact in Alaska and would inevitably lead to more collaboration with Alaskan research organizations and Alaskan energy companies. DOE's Grid Modernization Initiative may be a source of financial support for some of these projects. Resulting research could lead to innovative technologies for low-cost resiliency across isolated community power systems, prototype development and deployment of energy storage systems, and better assessment of how advanced-energy integration can help isolated communities for both primary needs: heat and transportation. Likewise, there are many opportunities to work with the Department of Defense in expanding the resiliency of Alaskan DoD facilities and operations.

    Within the framework of the DOE Energy Transition Initiative (which already includes Alaskan organizations), NREL and other national laboratories could support initiatives for building cost-effective, resilient energy infrastructure for remote communities. This could boost engagement through the DOE Office of Indian Energy Policy and Programs in the development of community energy planning in the nation's northernmost state. A more detailed assessment of existing microgrids—including, but not limited to, a detailed operational analysis of those renewable energy projects already on the ground in Alaska—could identify failure points and provide recommendations for how to better incorporate high contributions of renewable energy into isolated power systems.

- *Are there opportunities for the federal government to make better use of local entities like the Cold Climate Housing Research Center in Fairbanks, Alaska?*

  There are numerous opportunities to better include Alaskan entities in federal research and deployment of clean energy technologies. Agencies such as the Cold Climate Housing Research Center (CCHRC) and the Alaska Center for Energy and Power represent good partner organizations with which to conduct research and support the development and deployment of innovative technologies in cold climates. Other organizations such as the Alaska Energy Authority (AEA) and Alaska Native Tribal Health Consortium have a long-standing record of

successful work with remote communities to meet local plans for using microgrids and related advanced-energy technologies to fulfill their economic and sustainability goals.

Organizations such as the Renewable Energy Alaska Project and the Alaska Power Association allow engagement with utilities and other energy stakeholders. This provides greater understanding of energy needs, which can serve as a model for continued advanced-energy deployment across the rest of the United States and internationally. Federal funding for data monitoring and collection, along with the sharing of best practices for these systems, could greatly improve microgrid configurations and bolster ongoing DOE and Department of State outreach and development efforts.

Much of the current funding for Alaskan research, however, is structured so that these in-state entities end up competing, rather than partnering, with national laboratories. Developing long-term funding mechanisms that encourage appropriate partnerships would benefit Alaskan organizations and communities, not to mention the federal energy research portfolio.

Such partnerships could ideally pair the unique capabilities of NREL and other national laboratories with Alaskan organizations and government entities, an important relationship for technology validation, pilot projects, and application deployment. This could facilitate R&D that otherwise could not be done by federal researchers alone—such as real-world cold-climate testing—and at the same time could yield critical energy, economic, and environmental benefits on the ground in Alaska. Much of today's project-based funding exacerbates a perennial feast-or-famine situation for Alaska organizations. This lessens the effectiveness of work that is intended to solve Alaska-specific energy challenges. In contrast, programs that could incentivize longer-term, integrated research funding would encourage new collaborations between various entities (e.g., visiting researcher, sabbatical funding, etc.), which would strengthen scientific and technological progress for all parties. Sustained support for partnerships and collaborations is key.

Energy costs in rural Alaska are some of the most economically onerous in the country. The Alaska Industrial Development and Export Authority (AIDEA)/AEA is charged with keeping costs as low and stable as possible. But limited funding and staffing doesn't sustain research on the necessary mechanisms to increase stability—and thus economic resilience—in remote energy systems. Although these organizations work tirelessly to engage communities, they often lack the ability to engage in larger research efforts that would support the innovative technology evolution critical to addressing future energy issues in Alaska.

Partnerships such as the Alaska Microgrid Partnership have proved that state organizations have the field relationships and expertise to expedite and increase the success of advanced-energy solutions for those who need it most, especially Alaska's indigenous population.

Finally, while it is obviously true that much of the research done in Alaska is cold-climate specific, history shows that this work can deliver benefits for other regions and contexts as well.

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For example, NREL is currently working with 60 Hertz—an Alaskan energy-management startup that grew out of the Launch Alaska Incubator—to adapt its rural utility management app for use in rural electrification internationally. This type of research is currently furthering NREL's work in Colombia, where the U.S. Agency for International Development (USAID) is seeking to increase access to electricity and provide for increased political stability. Similar applicability can be found with work NREL is conducting in support of the USAID Power Africa initiative. A number of nations in sub-Saharan Africa and Southern Asia see new technologies as critical to their own advanced-energy systems development. It's important to note that the lessons learned from all of the above could create valuable new technologies for U.S. industries to export internationally.

Research conducted on microgrid solutions and energy efficiency in cold climates, including cold-climate approaches to housing, can be applied more broadly to other Arctic regions and states. NREL is currently working to support National Resources Canada in addressing the country's dependence on fossil fuel generation for Arctic communities. Strong existing linkages between Alaskan and Canadian organizations now exist, though a lack of adequate funding threatens successful collaborations. Expanded resources would foster more direct collaboration between Alaska's technical organizations and similar Canadian organizations, with innovation paybacks on both sides of the border. Funding for efforts such as the Arctic Remote Energy Networks Academy would provide additional opportunities for regional collaboration.

Question 4: In your testimony, you mention new ways that "bio-based" materials are being put to use by the National Renewable Energy Laboratory. What are the possible impacts that biomass can have on our energy futures?

In general, the development of a bioeconomy in the United States—in which plant-based materials are converted to fuels, chemicals and polymers—has two major benefits. The first is the ability to take advantage of abundant and relatively untapped U.S. resources for domestic economic benefit. The United States is blessed with thriving agricultural and forest industries that produce underutilized residues and wastes from their production of food and various products. In addition, there are vast expanses of marginal lands that, while not suitable for food crops, *are* suitable for dedicated energy crop production. This combination could sustainably produce around a billion tons of biomass annually (2016 Billion-ton report: advancing domestic resources for a thriving bioeconomy, volume 1: economic availability of feedstocks https://www.energy.gov/eere/bioenergy/downloads/2016-billion-ton-report-advancing-domestic-resources-thriving-bioeconomy). If converted to fuels, chemicals, and other products, the impact could offset approximately one-third of U.S. petroleum use—all from a domestic resource while significantly boosting our domestic economy.

The second benefit is that plants, in their growth cycle, utilize carbon dioxide (CO_2) from the atmosphere. Analysis shows that bio-based technologies could reduce life-cycle greenhouse gas emissions by 85%, compared with conventional resources and methods

(Supply Chain Sustainability Analysis of Renewable Hydrocarbon Fuels via Indirect Liquefaction, Ex Situ Catalytic Fast Pyrolysis, Hydrothermal Liquefaction, Combined Algal Processing, and Biochemical Conversion: Update of the 2018 State-of-Technology Cases and Design Cases https://greet.es.anl.gov/publication-supply_renewable_hc).

This potential route to abundant, domestic, low-carbon fuels, chemicals, and polymers is another strong reason the concept of a bioeconomy has so much appeal. How are NREL and others developing these opportunities to make a bioeconomy a cost-competitive reality? Let's first explore biofuels. Plants, in the form of cellulose and hemicellulose, consist of sugars that can be relatively easily converted to ethanol through well-established processes. Starch-based ethanol constitutes about 10% of the gasoline used in the United States today.

Biomass-derived, or "cellulosic," ethanol technologies have been developed to a point of cost-competitiveness (NREL 2012: Achievement of ethanol cost targets: biochemical ethanol fermentation via dilute-acid pretreatment and enzymatic hydrolysis of corn stover https://www.nrel.gov/docs/fy14osti/61563.pdf). But the U.S. market has not accepted much beyond the current 10% ethanol-gasoline blend levels in gasoline. Trends toward better fuel economy and more electrification of the light-duty vehicle fleet are raising questions about when, or to what extent, higher level blends will reach the market. As a result, much biofuel R&D has shifted toward infrastructure-compatible hydrocarbon fuels, especially those suited for heavy-duty applications and the marine and aviation fuel markets. In other words: researchers are using biomass to create fuels that are indistinguishable from current gasoline, diesel, and jet fuels.

This is particularly appealing from the perspectives of economics—and the ability to utilize existing refinery infrastructure. One recent example NREL developed with industrial partners involves "pyrolysizing" biomass to a bio-oil that can be blended with conventional refinery streams and processed seamlessly into gasoline and diesel fuel (*Biodiesel Magazine* article http://www.biodieselmagazine.com/articles/776356/ensyn-biocrude-receives-carb-approvals-for-refinery-coprocessing). This is an example of how the United States can seamlessly take effective advantage of our current refinery infrastructure to provide a cost-competitive pathway to produce fuels with a much lower carbon footprint.

A second area of interest is biomass-based chemicals or polymer precursors. Sugars are chemically different from petroleum in that they contain a significant amount of oxygen. This fundamental difference in chemical makeup makes it easier, more efficient, and potentially cheaper to produce some (though not all) chemical molecules using biomass-derived sugars, rather than petroleum as a starter material.

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One recent example that combines a hybrid biology-chemistry approach is the development of renewable carbon fiber. Carbon fiber is a high-performing, lightweight structural material that is used sparingly today, but has the potential to be used much more broadly if it could be produced at a lower cost. A major impediment to making carbon fibers more affordable is the existing cost of its precursor, the "building block" molecule acrylonitrile, which conventionally is produced from petroleum through a complex, energy-intensive chemical process. At NREL, we have developed a completely different but easier, more environmentally friendly, and cheaper route to produce acrylonitrile from sugars. It combines a process to selectively ferment sugars with a novel chemical catalysis system, making biomass-derived acrylonitrile well suited for carbon fiber production technologies.

This innovative biomass-based catalytic step won a coveted R&D 100 Award (https://www.nrel.gov/news/press/2018/rd-magazine-honors-duo-of-nrel-innovations.html; https://www.nrel.gov/news/press/2017/nrel_develops_novel_method_to_produce_renewable_acrylonitrile.html; https://www.nrel.gov/news/program/2018/nitrilation-process-produces-acrylonitrile-attention-awards.html; https://www.nrel.gov/news/features/2018/nrel-shifts-carbon-fiber-research-into-second-gear.html). It is currently being scaled up to commercialization with a goal of testing the resulting renewable carbon fiber for vehicle applications by Ford Motor Company. This process could become key to the affordable light-weighting of cars and trucks and, therefore, to significantly improving their fuel economy. This is just one example in which biomass can be more efficient than petroleum in producing value-added chemicals and end products.

Finally, I should discuss NREL's important biomass research focused on solving a broader set of societal challenges. One project involves direct CO_2 conversion. Many of the biological and chemical strategies we employ for biomass conversion can also be used to either reduce or convert CO_2 to other useful products. An NREL project now underway, with Southern California Gas Company explores the use of a biological organism to convert CO_2 and renewable hydrogen to methane (or renewable natural gas), a product of increasing future demand, driven in part by policies of the nation's most populous state, California. (Related television news story: https://denver.cbslocal.com/2019/03/03/nrel-archaea-renewable-natural-energy/.)

Another far-reaching program could lead the way to dramatic improvements in plastics recycling/upcycling and engender a circular economy for one of the world's most ubiquitous and least-recycled products. While we may all use plastics in our everyday lives, their environmental impacts loom larger each year as an environmental and societal concern. Current recycling practices are mechanical in nature and tend to produce a lower-value material than the original plastic. This means that most products get recycled (at

best) only once before ultimately finding their way into landfills—or worse, into the world's oceans.

NREL and an international collaboration of research partners are working on a chemical recycling process that would break plastics down into their individual chemical building blocks, then rebuild them to produce higher-valuable materials. In collaboration with academic partners, NREL recently published a groundbreaking study showing that the kind of enzymatic approach traditionally used to degrade plant material into simple sugars can feasibly be used to reduce plastics into their original chemical building blocks, too (https://www.pnas.org/content/115/19/E4350; https://www.bbc.com/news/science-environment-43783631). This could be the missing link to the much-hoped-for circular economy for plastics.

These are merely a few of the instances in which the biomass-based technologies developed at NREL and across the scientific community are helping forge our energy future. NREL partners with more than 800 private and public academic and industry entities in all areas of energy efficiency and advanced energy technology. Encouragingly, this list is expanding to include global energy giants such as ExxonMobil and Shell, which embrace an all-of-the-above strategy for low-carbon energy (https://www.nrel.gov/news/program/2019/exxonmobil-partnership-will-support-national-lab-research-for-future-energy-solutions-at-scale.html; https://www.nrel.gov/news/program/2018/nrel-and-shell-launch-accelerator-program-for-emerging-technologies.html).

Questions from Ranking Member Joe Manchin III

Question 1: As I understand it, a major challenge to greater manufacturing and adoption of renewable energy technologies is access to critical minerals. How is lack of a stable supply of critical minerals impacting our ability to increase renewable generation?

Concerns regarding the availability of critical minerals used in renewable technologies have increased as deployment of renewables has increased. But in general, from a production perspective, the supply of critical minerals is not currently a constraint on the ability to scale up renewable generation when comparing the available global reserves of critical minerals to the anticipated demand for these minerals for renewable technology manufacturing. In most cases, renewable technologies still use only a small portion of the critical minerals relative to other uses. For example, based on estimated battery designs and 2015 electric and hybrid electric vehicle (xEV) sales figures, approximately 4% of lithium, 2% of cobalt, and 16% of manganese (as well as less than 1% of nickel and 1% of graphite) produced in 2015 were used for xEV battery manufacturing.

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However, critical minerals can be considered a supply risk subject to prevailing geopolitics, regional governmental stability, environmental issues, and worker health concerns in countries that own these critical minerals. These concerns are warranted because these minerals are generally produced as byproducts of other materials (which means they are dependent on demand of the primary mineral to some extent) or are highly concentrated in a few countries (which means they could be vulnerable to supply-chain disruption) or both. Rapid changes in trade and supply in the global materials market can result in price spikes that affect downstream technology prices and manufacturing locations.

Question 2: What sector – wind, solar, battery storage – is most vulnerable to a shortage of minerals in its supply chain?

Most research has focused on assessing potential supply risk of an individual mineral to a technology rather than comparing vulnerability across technologies. The research published by DOE in 2011 assessed the critical materials for solar, wind, batteries, and LED lighting in terms of supply risk and importance to clean energy (DOE 2011 Critical Materials Strategy Report https://www.energy.gov/sites/prod/files/2016/12/f34/2011%20Critical%20Materials%20Strategy%20Summary.pdf). The U.S. Geological Survey compiles an annual Mineral Commodity Summary that indicates the extent to which the United States relies on imports for select minerals (USGS/DOI Mineral Commodity Summaries 2019 http://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs2019_all.pdf).

The attached table shows the most recent results of these two assessments. Heavy reliance on imports, which is the case for rare earth elements (REE), combined with higher estimated supply risk could indicate greater vulnerability.

For the wind sector, risk applies primarily to offshore applications that depend on higher reliability due to the challenges associated with access for maintenance and repair. To achieve the requisite reliability, offshore turbines typically depend on rare earth permanent magnets in direct drive generators. As the offshore wind sector is working hard to reduce costs and increase competitiveness, supply constraints on rare earth elements could erode opportunities for an industry that has recently begun to play a substantive role in the U.S. electricity sector. Onshore wind turbines have reduced their exposure to rare earth element supply constraints through the use of other generator technologies coupled to gearboxes—at the cost of more frequent maintenance and repair event but without significantly impacting technology economics.

For solar, as indicated in the table attached, the materials required for PV do not currently have significant supply chain risk. For battery storage, see the discussion in the previous

question about their technical availability but potential risk due to limited number of countries as primary sources.

That said, criticality of a material is a dynamic issue and the list of critical materials varies year to year depending on changes in supply risk of a particular mineral and its importance to the technologies it serves. While collaborative efforts are underway among DOE, national laboratories, and industry to address the vulnerability of all technologies to critical materials, much work remains to done in this area. The ever-changing environment and lack of public information about the production and consumption of these critical minerals present a challenge in effective tracking of their supply risk.

***Question 3*: What resiliency measures is the government and the industry undertaking to prepare for potential disruptions?**

Government and industry are both focused on a diverse set of resiliency measures. DOE's strategy for addressing critical materials challenges has three pillars, and industry is generally in concurrence. (https://www.energy.gov/sites/prod/files/2016/12/f34/2011%20Critical%20Materials%20Strategy%20Summary.pdf)

- **Establish diversified global supply chains**: To manage risk, multiple sources of materials are required. As shown in the attached table, while the United States imports virtually all the REE used in renewable technologies, these REE can all be imported from multiple countries.
- **Develop substitutes**: Research leading to material and technology substitutes will improve flexibility and help meet the material needs of the clean energy economy.
- **Expand recycling, reuse, and more-efficient use to lower demand for newly extracted materials**: Research into recycling processes coupled with well-designed policies will help make recycling economically viable over time.

For wind technologies specifically, these measures also include research into alternative means to create permanent magnets, design strategies that minimize the content of REE in wind turbines, and design alternatives that eliminate REE from wind turbines entirely. Based in part on these resiliency measures and ongoing research, risk due to critical mineral supply is an issue the industry continues to track and monitor, but it is not one that has precipitated aggressive action in the recent past.

Other measures include:

- **Securing the supply chain**: Some of the key industry players are becoming more vertically integrated by acquiring assets along the renewable supply chain (from mining of critical minerals to manufacturing of components) to ensure availability of raw materials. International communities, the end users of critical materials and final products, and nongovernmental organizations are pushing for responsible and low-carbon sourcing to

address environmental and health concerns in resource countries. These efforts serve to address supply risk of critical minerals.

- **Material substitution:** In the long term, R&D efforts are looking to develop wind, solar, or battery technologies that do not depend on critical materials. For example, in battery storage technology, the solid-state battery technology is a potential substitute to lithium-ion battery technology in electric vehicles, while the flow battery technology is a potential substitute of lithium-ion battery technology in energy storage. Most of these technologies are still at discussion/research level and they may not commercialize soon.
- **Recycling**: For PV modules and batteries, recycling has come to the forefront as the first solar panels and plug-in electric vehicle batteries near their end of life. For example, the February 2019 launch of DOE's first lithium-ion battery recycling center, called the ReCell Center, will spur development of new recycling techniques and battery designs to help the United States grow a globally competitive recycling industry and reduce our reliance on foreign sources of battery materials. In the long term, industry and national laboratory R&D spending that focuses on improving the recovery rate of critical materials from the ore and recycling processes is likely to address supply risk. Many existing research studies indicate that recycling output is going to play a significant role as input to renewable technology production in the future.
- **Reducing material intensity**: Over the years, industry has been dedicated to reducing the use of critical minerals in manufacturing of renewable technologies through reduction of material intensity. For example, manufacturers of Nickel Cobalt Aluminum batteries have reduced the use of cobalt from 14% to less than 4%, while Nickel Manganese Cobalt batteries expect to reduce cobalt content to around 9%.

Questions from Senator Mazie K. Hirono

Questions: During the hearing, you stated that NREL is working with about 90 different countries. Is NREL active in Vietnam, and if so, what is NREL doing to help Vietnam develop renewable energy resources and build a clean, reliable, and accessible energy system? Has NREL identified other actions it could take to achieve those objectives in Vietnam or other counties in Southeast Asia with additional funding from Congress or cooperation from other agencies?

NREL is providing analytic and technical assistance to the government of Vietnam and other Vietnamese partners to support comprehensive power development planning and prepare for higher levels of variable renewable energy on the country's grid. This includes training on the use of state-of-the-art data, modeling, and analysis to inform Vietnam's Eighth Power Development Plan, as well as broader technical analysis and assistance on advanced energy technologies and systems, market structures and private sector engagement. This work is sponsored by USAID, the State Department, the Children's

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Investment Fund Foundation, and the Hewlett Foundation. All activities are conducted in close coordination with the USAID mission in Vietnam.

Work to date includes guiding methodological updates to the process, providing training on best analytical practices to inform power plan development, and creating a framework for an interagency Modeling Working Group to jointly undertake power planning analyses. NREL, together with USAID and other partners, has also developed data and tools to support renewable energy development in Vietnam, including the Renewable Energy Data Explorer with high-quality wind and solar resource data to enable identification of potential project sites. Additionally, NREL, through the Clean Energy Investment Accelerator (CEIA), is working to create a robust corporate renewable energy procurement market by identifying innovative project pipelines, engaging with the Ministry of Industry and Trade to inform private sector perspectives on market design, and building capacity of private sector partners to replicate effective models.

In the coming 1-2 years, NREL plans to continue to work with USAID and other partners to assist Vietnam in incorporating advanced modeling of power system operations to evaluate the operational feasibility of capacity expansion scenarios conceived through the power planning process. NREL will also analyze market opportunities for battery applications and assess the implications of utility remuneration models for behind-the-meter distributed solar. Additional work on corporate procurement will include collaborating with Vietnam Low Emissions Energy Program to pilot direct power purchase agreements and facilitate business-to-business renewable energy sales.

In addition to Vietnam, NREL is working with the governments of Indonesia and the Philippines to support modernization of their power systems with respect to generation capacity, grid stability and renewable energy integration. In Indonesia, this includes working with the Ministry of Energy and Mineral Resources and the national utility to conduct analysis, provide tools, and improve institutional technical capacity for utilizing analytical results toward efficient and cost-effective energy system planning. Further, NREL is working with in-country private-sector partners through the CEIA to identify market challenges and explore innovative applications of international best practices toward the improvement of the investment environment for renewable energy technologies.

In the Philippines, NREL is supporting private sector investment through the CEIA by training and developing tools for privately owned distribution utilizes on renewable energy procurement pathways to meet the Renewable Energy Portfolio Standards. NREL and other partners is also facilitating public-private partnerships between local government units and large commercial and industrial customers to aggregate renewable energy power purchase agreements in bulk to further create markets and drive down costs. NREL together with Lawrence Berkley National Laboratory (LBNL) recently conducted analysis

and training on the impacts of integrating distributed photovoltaics on the grid and potential rate impacts for distribution utilities. NREL, LBNL, USAID Clean Power Asia, and the CEIA are currently supporting a joint effort at the request of PDOE to help facilitate public consultations on a new net metering policy and develop analytical inputs on market and policy options.

NREL is pleased to explore opportunities to deepen the above activities in Indonesia, the Philippines, and Vietnam, and potentially expand the scope to other Southern Asian countries, in close consultation with the U.S. Department of Energy, Agency for International Development, the State Department and in-country and international partners.

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[No Response Received as of the Date of Printing]

Question from Chairman Lisa Murkowski

Question: With the phase-out of residential Investment Tax Credits at the end of 2021 it is important to continue innovating and driving down solar costs. Where should we focus research and development efforts on solar to maximize the odds of a strong domestic solar future?

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Questions from Chairman Lisa Murkowski

Question 1: What is your perspective on the role the Department of Energy's Appliance and Equipment Standards Program plays in the overall energy efficiency landscape?

Energy conservation standards are among the most impactful and cost-effective policies for cutting energy and water waste and lowering energy bills for U.S. consumers and businesses. The typical U.S. household saves about $500 each year because of national standards for consumer products.[1] U.S. businesses also save money – an estimated $23 billion in 2015 alone – due to existing standards for equipment used in commercial buildings and industry.[2] The Department of Energy (DOE) estimates that cumulative savings from already existing appliance standards will exceed $2 trillion by 2030.[3]

Standards and complementary policies can also spur energy-saving innovations. Research and development of sensor and controls technologies has contributed to changes that save American households and businesses billions of dollars in avoided utility costs.[4] When paired with highest-efficiency products covered by the energy conservation standards these can be critical building blocks for systems efficiency, creating whole-building efficiencies beyond the component level. As buildings become more efficient, the energy consumption of appliances and equipment can have twice the impact, reaching half of the energy consumption of highly efficient commercial buildings.

Innovations brought on by the standards program have also benefited consumers who now enjoy a richer appliance marketplace. When the program was first put into place DOE had concerns that the price of appliances would rise somewhat.[5] In retrospect we know from the data that this has not happened. Take, for example, refrigerators. They now cost half as much as they did in 1972 in real prices, have nearly a fifth more space,

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[1] Appliance Standards Awareness Project, *Appliance Standards Questions and Answers* (2017) (online at appliance-standards.org/sites/default/files/Why_National_Appliance_Standards%202017_0.pdf).

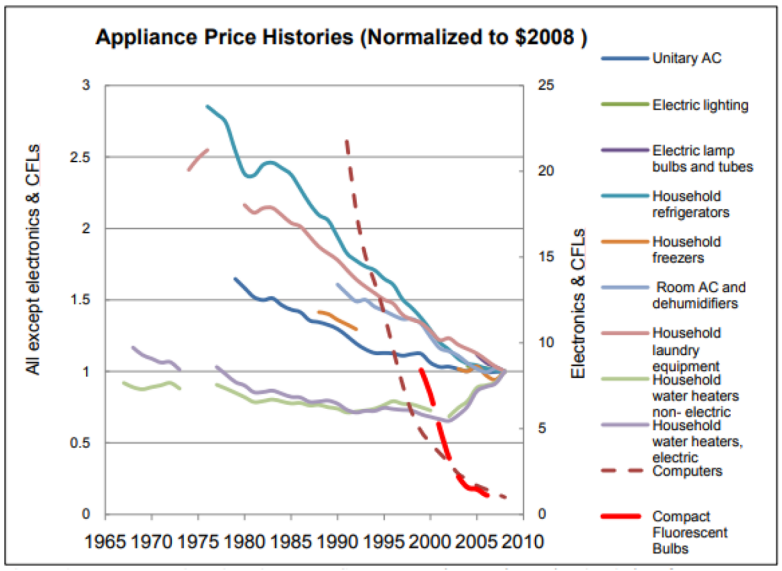
[2] deLaski, Andrew and Mauer, Joanna, *Energy-Saving States of America: How Every State Benefits from National Appliance Standards*, Appliance Standards Awareness Project and the American Council for an Energy-Efficient Economy (Feb. 2017) (online at appliance-standards.org/sites/default/files/Appliances standards white paper 2 2-14-17.pdf).

[3] Department of Energy, *Saving Energy and Money with Appliance and Equipment Standards in the United States* (Jan. 2017) (online at www.energy.gov/sites/prod/files/2017/01/f34/Appliance%20and%20Equipment%20Standards%20Fact%20Sheet-011917_0.pdf).

[4] Alliance to Save Energy comments in response to the Department of Energy's Request for Information on Research and Development Opportunities for Innovations in Sensors and Controls for Building Energy Management, 84 Fed. Reg. 17148 (Apr. 24, 2019).

[5] Appliance Standards Awareness Project, *Appliance Standards: Comparing Predicted and Observed Prices*, Report E13D (Jul. 2013) (appliance-standards.org/sites/default/files/Appliance_Standards_Comparing_Predicted_Expected_Prices.pdf).

and use 75% less energy.[6] Similar trends can be observed in sales of washing machines, dishwashers, and air conditioners, which all use significantly less energy than they did in 1990 while there prices have continued to fall.[7]



The cost savings for energy-efficient products also move in parallel with an increasing variety of choices. Light bulbs are a prime example of how standards have stimulated innovation, resulting in more consumer options in wattage, color, and warmth. Consumers who walk down the lighting aisle at a retail store can now find a wide variety of options that use up to 80% less energy than traditional incandescent bulbs.[8]

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[6] Appliance Standards Awareness Project, *Average Household Refrigerator Energy Use, Volume, and Price Over Time* (Nov. 2016) (online at appliance-standards.org/sites/default/files/refrigerator_graph_Nov_2016.pdf).

[7] Department of Energy, Office of Energy Efficiency and Renewable Energy, *Using the Experience Curve Approach for Appliance Price Forecasting* (Feb. 2011) (online at www1.eere.energy.gov/buildings/appliance_standards/pdfs/experience_curve_appliance_price_forecasting_3-16-11.pdf).

[8] Department of Energy, *How Energy-Efficient Light Bulbs Compare with Traditional Incandescents* (www.energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money/how-energy-efficient-light) (accessed Jun. 7, 2019).

Energy conservation standards also support an American workforce. Standards sustained or created roughly 300,000 in 2016, and that number will nearly double by 2030.[9]

Standards also support American jobs because innovative, efficient appliances trade on design and high-tech manufacturing that are strengths of American industry. Countries with cheaper labor have an advantage when manufacturing low-cost inefficient appliances.

Question 2: In your testimony you highlight the jobs component of energy efficiency efforts. Energy efficiency jobs make up about 70 percent of all the clean energy jobs in the country. Given that figure, where do you see the biggest remaining opportunities for domestic energy efficiency gains?

There is great untapped potential to realize domestic energy efficiency gains in older rental housing, rural areas, and low-income populations. DOE's Office of Energy Efficiency and Renewable Energy (EERE) has published maps which show the energy-efficiency potential of each state across several metrics measure out a decade or more.[10]

Buildings are major source of energy use in the U.S., consuming 75% of all electricity.[11] As much as 80% of peak demand is driven by building energy use. Load flexibility can take stress off of the electricity sector by shifting the timing of building energy consumption. Building-to-grid communications can support load flexibility by allowing utilities to incentivize consumers to shift energy usage to off-peak times.[12] Vehicle to grid communications and charging, which happen through building infrastructure, can have similar benefits. Thermal storage can also help shift this load to maximize energy use.

Despite incredible advancements in building design, which can cost-effectively achieve net-zero in many building categories, existing buildings hold the greatest potential for energy reductions. According to DOE's Pacific Northwest National Laboratory, existing federal buildings could reduce federal energy use intensity (EUI) by nearly 20% over efficiency gains due to new construction by 2025.[13] With appropriate incentives and access, American homes could also achieve significant savings and would boost

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[9] American Council for an Energy-Efficient Economy, *Jobs Created by Appliance Standards* (Jul. 24, 2018) (aceee.org/research-report/a1802).

[10] Department of Energy, *U.S. Energy Efficiency Potential* Maps (accessed Jun. 13, 2019) (www.energy.gov/eere/slsc/us-energy-efficiency-potential-maps).

[11] Energy Information Administration, *Annual Energy Outlook 2018* (Feb. 6, 2018) (online at www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf).

[12] Alliance to Save Energy, *DOE Looks to the Future: Energy Efficient and Flexible Building Loads Cut Costs and Increase Grid Reliability* (Mar. 6, 2019) (www.ase.org/blog/doe-looks-future-energy-efficient-and-flexible-building-loads-cut-costs-and-increase-grid).

[13] Pacific Northwest National Laboratory, *Analysis of Federal Agency Facility Energy Reduction Potential and Goal-Setting Approaches for 2025* (May 2014) (online at www.pnnl.gov/main/publications/external/technical_reports/PNNL-23063.pdf).

employment in local small business involved in audits, retrofits, and product installation.[14]

We can significantly improve our water efficiency efforts - it takes energy to get water, and it takes water to get most energy. The policies that encourage us to use one more efficiently often reduce our need for the other.[15] Energy is used to decontaminate the water and to pump it to your faucet (about 80 percent of a drinking water utility's electricity use).[16] Wastewater treatment facilities use energy too. Every gallon of water saved is a gallon that is not pumped, treated, or delivered.[17]

Water also plays a notably outsized role in power generation. Most power plants need water both to create steam for turbines as well as for cooling equipment.[18] More than four times as much water is withdrawn to support power generation across the U.S. than is used by our homes and commercial buildings combined.[19] We must think about water efficiency when using energy, just as much as we must think about energy efficiency when using water.

The transportation sector account for about a third of all energy used in the U.S. today, and it is currently responsible for more greenhouse gas emissions than power plants. The Alliance to Save Energy's 50x50 Commission was formed to address the challenges facing U.S. transportation sector efficiency by finding ways to reduce energy use 50% by 2050.[20]

More efficient vehicle types, including electric vehicles, hybrids, and highly efficient vehicles running on natural gas are emerging to serve different needs, ranging from cars to buses, heavy duty trucks, and other non-road vehicles like forklifts and cranes. These new technologies allow us to address energy use in vehicles in ways which were previously not possible. A transition to an integrated "transportation services" model, where the most efficient transportation modes are integrated into a system-wide approach with other vehicle options can multiply the impact of vehicle efficiency. This approach will require strengthening public transportation systems; enhancing freight system

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[14] National Renewable Energy Laboratory, *Energy Efficiency Potential in the U.S. Single-Family Housing Stock*, NREL/TP-5500-68670 (Dec. 2017) (online at www.nrel.gov/docs/fy18osti/68670.pdf).

[15] Alliance to Save Energy, *Saving Water Goes Hand-in-Hand with Saving Energy. Federal Research Should Capitalize on Their Integration* (May 1, 2019) (online at www.ase.org/blog/saving-water-goes-hand-hand-saving-energy-federal-research-should-capitalize-their-integration).

[16] Congressional Research Service, *Energy-Water Nexus: The Water Sector's Energy Use*, R43200 (Jan. 24, 2017).

[17] Alliance for Water Efficiency, *Water Efficiency: The Key to A Sustainable Future* (www.allianceforwaterefficiency.org/infographiclp.aspx) (accessed Jun. 7, 2019).

[18] Water Footprint Calculator, *The Water Footprint of Energy* (Jul. 1, 2017) (www.watercalculator.org/water-use/the-water-footprint-of-energy/).

[19] Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities* (Jun. 2014) (www.energy.gov/sites/prod/files/2014/07/f17/Water Energy Nexus Executive Summary July 2014.pdf).

[20] Alliance to Save Energy 50x50 Commission on U.S. Transportation Sector Efficiency, *50x50: Reinventing U.S. Mobility* (Sept. 26, 2018) (online at www.ase.org/sites/ase.org/files/ase-50x50-full_policyreport-final.pdf).

efficiencies; reducing passenger vehicle miles traveled, facilitating transitions among different transportation modes; and enhancing systems at transportation hubs.[21]

Low-income Americans in both rural and urban areas spend a far greater share of their income on energy costs and are struggling to keep up. Nearly 25 million American households are forced to choose between buying food and medicine or paying their energy bills.[22] Finding solutions to decrease low-income Americans' energy use can help lower these costs and would be a major relief for struggling families. Weatherization retrofit programs are one way to help low-income families cut down on their utility bills by reducing the need to run heating and cooling appliances. The Weatherization Assistance Program is one tool that Congress has used to help more millions of families, and for every dollar invested in the program $1.72 is created in energy benefits and another $2.78 in other benefits.

Each of the above challenges presents an opportunity to grow the American workforce. Skilled workers are needed in building retrofits, water treatment, transportation, and weatherization. However, employers in the energy efficiency report high levels of difficulty recruiting new employees.[23] The energy efficiency sector added 76,000 new jobs in 2018, a 3.4% rate of growth. Employers predict more than double that, 7.8%, in 2019. There is an opportunity for Congress to engage on this issue to help facilitate training workers for these jobs.

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[21] *Id.*

[22] Alliance to Save Energy, *Alliance Welcomes Bill to Speed Home Weatherization Funding* (Jan. 23, 2019).

[23] National Association of State Energy Officials and the Energy Futures Initiative, *The 2019 U.S. Energy and Employment Report* at 132 (2019) (static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f3708fa0d6036d7120d8f/1551849054549/USEER+2019+US+Energy+Employment+Report.pdf).

U.S. Senate Committee on Energy and Natural Resources
May 21, 2019 Hearing: *Opportunities to Advance Renewable Energy and Energy Efficiency Efforts in the United States*
Questions for the Record Submitted to Mr. Bruno C. Grunau

Questions from Chairman Lisa Murkowski

Question 1: *You represented the Cold Climate Housing Research Center at the National Lab Day event in Fairbanks, Alaska last year.*

- *Can you describe any partnerships, ideas, or other proposals that have evolved as a result of National Lab Day?*

Accomplished
On National Lab Day 2018, Senator Murkoswki hosted a roundtable discussion to explore commercialization as a potential solution for addressing climate change issues. Since then, CCHRC has been involved with some very interesting work with industry partners on advancing the practical use of advanced materials in building assemblies. This includes testing and evaluating a new insulation technology which has the potential to drastically reduce carbon footprint of housing energy and potentially transform the housing in rural Alaska and across the world. We are actively involved in finding solutions that address the high cost of construction of energy efficient homes that are culturally and environmentally designed for the people of our state.

Developing
Taking an energy-efficiency approach, we'd like to develop a super-efficient modular housing concept that addresses local and cultural design needs, that enables communities to build homes that use little energy, can adapt to changing ground conditions, and can be transported in the case that communities need to move.

CCHRC is developing a high-performance modular building system that makes energy efficiency available to everyone by integrating vacuum insulated panel (VIP) technology into a simple, component-based system. Bridging the gap between conventional housing and manufactured housing, this affordable, flat-pack building system combines proven and widely used building components with the most advanced insulating materials available to create a modular building kit. It uses a structural frame with a curtain wall glazing system; panels form a curtain wall around the frame similar to the way windows are hung outside the structural frame in a glass office building. The VIP is sandwiched between protective layers to create a complete building envelope and ensure the vacuum is not compromised.

This system lowers the upfront cost of building as well the ongoing cost of energy for home occupants. Components are designed to be lifted and fitted together without the use of heavy equipment. The "flat-pack" system means the entire home can be shipped and assembled without a skilled builder, the same way you would put together an IKEA modular closet system. These advantages provide significant cost savings throughout the construction process.

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The greatest advantage of this system is that it provides a net-zero-energy-ready home at an affordable price. With R-60 wall components, this system far exceeds the efficiency standards required by the 2018 IECC building code.

In addition to being thermally efficient, this system is also durable against the elements. The VIP panels incorporate all aspects required in a durable envelope, including consistent application of insulation and air and vapor sealing, largely removing the factor of human error from the building process. Coupled with effective heating and ventilation systems, the home is healthy to live in.

The kit system is easily shipped and assembled on-site with limited infrastructure. It can be used virtually anywhere by anyone with limited building skills. It uses a standardized grid layout for the structural frame and panel system that allows the consumer to configure their home to suit their needs. Like LEGO® building blocks, individuals can assemble components into a wide variety of configurations.

This system builds on our experience developing high-performing and affordable homes for challenging climates. CCHRC has built more than 20 different demonstration homes across the state, working closely with indigenous Alaskans to incorporate traditional knowledge into building designs. In the village located inside the Arctic Circle, CCHRC partnered with a local tribal housing authority to design and build an affordable, superinsulated home that cut heating costs by 80%. That home was built for half the cost of an average home in the region by minimizing shipping and labor costs. Because the village is only accessible by plane, we ensured all building materials could fit on one cargo plane. The design was simple enough to be built by a local crew with limited construction experience.

CCHRC is searching for funding, including applying through DOE's Energy Efficiency and Renewable Energy (EERE) Program grant process to help enable us to build and test a prototype of system components. Moreover, testing VIPs in modular homes will pilot a path to using them in conventional and low-income housing construction and ultimately transforming the building industry.

- *Are there opportunities for the federal government to make better use of local entities like the Cold Climate Housing Research Center?*

The Cold Climate Housing Research Center has 20 years of experience making buildings more energy efficient, healthy, and affordable for Alaskans. Since our founding in 1999, we have received core funding from the Alaska State Legislature in support of this mission. The Research Center has had remarkable success in lowering the cost of housing and improving energy performance not only in Alaska but in other regions of the U.S. with extreme weather and high costs. Through product testing, demonstration homes, and collaborations with industry and

government partners, CCHRC has driven the creation of more affordable, energy efficient and healthy buildings for our nation.

CCHRC has the capacity to work with multiple federal partners to ensure healthy, climate-appropriate housing for military, agency personnel, and rural communities. In the past, CCHRC has teamed up with FEMA and the Army Corp of Engineers to design disaster relief housing for Alaska communities devastated by flooding. Through a joint effort with U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) and the Alaska Center for Energy and Power (ACEP), we are partnering with the U.S. Dept. of Defense to ensure new housing for Alaskan soldiers is healthy and durable. CCHRC has played a key role in village relocations with U.S. Department of Housing and Urban Development (HUD), Bureau of Indian Affairs (BIA), U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), and the Denali Commission as climate change forces communities to adapt. Continuing and developing these partnerships is critical to meet the challenges presented by this time in history.

CCHRC's research is opening new frontiers in energy efficiency as we develop some of the most advanced building envelopes and mechanical systems on earth. Our demonstrations integrate renewable energy and high performing building systems to improve resilience and drastically reduce energy costs. Our work on indoor air quality, water, and wastewater is continually improving the health of homes and reducing rates of upper respiratory disease in Native communities. The work that has been so effective in Alaska transfers to northern and rural communities across the nation.

Nevertheless, inefficient, unhealthy, and inadequate shelter is being built every day across Alaska - many of these efforts, especially in rural Alaska, are paid for with federal dollars. This can be addressed in the following ways:

- Education and Training: Through workforce development, CCHRC can provide cold climate construction training to contractors, designers, builders, and laborers who build shelter in Alaska. Training can occur at the research center or staff can travel to regional hubs and communities where construction projects are occurring.
- Design: CCHRC can provide design services for rural housing projects by working closely with a community to create healthy, affordable, energy-efficient, and culturally-appropriate shelter based on sound building science.
- Demonstration: CCHRC can partner not only directly with communities but also with groups of contractors who work in rural Alaska to teach high-efficiency construction methods at our facility in Fairbanks. Demonstration projects make a big impact on housing: on Alaska's North Slope, for example, the housing authority TNHA built $12M worth of healthy, durable, and energy-efficient housing based on concepts demonstrated by

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CCHRC in the region. Federal support of similar demonstration projects would help advance these efforts across Alaska.

- Plan Review: To ensure all homes built with federal dollars are healthy and durable, CCHRC can provide design review on plans for all federally funded housing projects prior to construction, including village housing as well as employee housing for federal and state agencies (including health workers, researchers, contractors, etc.) Plan reviews catch problems and errors that could lead to poor energy performance or health risks for occupants.
- Consultation: An easy way to build on our strengths would be to offer consulting services to communities that are building housing. When CCHRC is not responsible for creating plansets and construction documents, our staff could provide consulting services to other design and construction firms working on federally-funded housing projects.
- Research and Proof-of-Concept: What separates CCHRC from other design/build firms is the way we use building science to advance design and construction methods. As we test and vet new building materials, we find ways to incorporate them into building design affordably and safely. The building industry can be slow to adopt new materials and construction methods because contractors are reluctant to try something new on the backs of their clients (which is why construction methods have barely changed in the past 100 years). This is where CCHRC comes into the picture. By working through the details and problems in our laboratory, we are able to overcome hurdles and integrate new technologies into existing building systems. The lessons learned are then applied to housing designs and shared with the building industry.
- Policy Development and Research: CCHRC's mission, skills, and work complement HUD's Office of Policy Development and Research (PD&R) Research Roadmap, which addresses priority research topics for HUD. For instance, PD&R's mission to provide "reliable and objective research on housing and community development that is relevant for HUD and for our constituents and enables informed policy decisions"[1] dovetails the work accomplished by CCHRC for Alaska.
- National Laboratories: CCHRC can work with national laboratories to test and advance building materials and systems appropriate for cold climates. Additionally, we can provide a third party review of performance metrics, grant management, or project development.
- Working with Tribes:
    - CCHRC has driven an approach to create a more sustainable and lasting change in rural Alaska by pushing a more community-driven approach to development projects. A pilot project funded by the U.S. Bureau of Indian Affairs worked with the tribal leadership in the village of Oscarville to address housing, energy, health, and economic needs together as one. This concept, called The Holistic Approach, leverages the resources of communities and outside agencies and ensures the dollars are being spent in the best interest of local residents.

[1] HUD Research Roadmap: 2017 Update. (January 2017). U.S. Department of HOusing and Urban Development | Office of Policy Development and Research.

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- To better support our work with Tribes, we are currently forming a Tribal Energy Development Organization (TEDO) in order to synchronize the many projects happening in villages. Grouping energy and housing projects together cuts down on administrative tasks and makes it easier to recruit contractors such as electricians because we can provide more work under one contract. Bulk purchasing reduces the cost of materials like LED lights and insulation. Furthermore, a group project between multiple tribes allows them to share lessons learned and fosters a sense of camaraderie when they see each other at gatherings like the annual Alaska Federation of Natives convention. **To the extent the federal government can encourage and support group applications under one contract, such as through eligibility requirements, scoring of applications, and ease of TEDO formation, it would pave the way for group projects that can achieve more cost-effective results.**

- Addressing the Complexities of Climate Change:
  - Perhaps nowhere on Earth are the challenges of adaptation more acute than the Arctic. Whole community relocation is occurring presently and dozens more communities are threatened. Despite what may appear to be an impossible task, Alaskans have shown that through collaboration between residents and agencies progress is made. With Alaska experiencing changing temperatures and conditions faster than anywhere in the nation, projects should be prioritized that: address energy efficiency retrofits and emissions; increase resiliency and account for future changing conditions; and save money in the long run. Single-sighted programs that address only efficiency miss the opportunity to increase occupant health and adapt to a changing climate.
    - *Example 1:* Ensuring weatherization retrofit programs also address things like adapting foundations for changing soil conditions would better prepare buildings for erosion and/or permafrost thaw.
    - *Example 2:* Retrofits to heating systems or envelopes that also include cooling (which will be a bigger issue worldwide than heating) ensures our most vulnerable populations of elders and children are not affected by extremely hot temperatures in the future.
    - *Example 3:* Allowing ventilation retrofits to include a filter box for ensuring clean indoor air during wildfires will keep us healthy and reduce health costs during wildfire effects.
- **Additional Support: The Cold Climate Housing Research Center requests a multi-year funding commitment from the federal government to continue our mission and expand our influence nationally. We also request support in becoming a federally recognized contractor. The same building science that is lowering energy costs and improving affordability for Alaskans can be applied in many environments globally. The state funding we have depended on for general operations has been cut by 50% over the last 5 years. We are working on commercializing some of our building and**

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heating technologies so our work has a greater impact and we can establish new financial opportunities. While this is facilitated by our strong connections in the building industry, it is nonetheless a great shift. As we make this transition to a more self-sustaining model, we cannot do it without government support.

Question 2: *Buildings today consume 40 percent of our primary energy and 75 percent of our electricity. How can we account for the unique Arctic challenges when determining the best way to capture the energy efficiency gains and emissions reductions available to the building sector?*

Efficiency is most economic in the Arctic. Because buildings consume such a huge portion of national energy use, energy efficiency is one of the best possible returns on investment. Nowhere is this more true than in the Arctic, where energy costs are highest in the nation and resources are fewest. Therefore, the cost savings of efficiency are realized fastest in the Arctic. Because of the extreme conditions and small margin for error, all housing in the north must be built on a foundation of energy efficiency and sound building science.

Focus on lowering energy costs for low-income people. In the Arctic, high housing and energy costs disproportionately impact low-income households. More than 30% of Alaska households are cost burdened, meaning they spend a third or more of their income on housing and energy. Any national efforts in energy efficiency such as weatherization should target those who can least afford high energy costs.

Adaptable housing: With a changing arctic comes the need for adaptable housing. As communities in the arctic are forced to relocate due to increased erosion and thawing permafrost, one solution is to create housing that can be easily moved.

Question 3: *From your perspective, what are the possible impacts of biomass on our energy futures?*

Biomass is a readily available, easily renewable energy resource. While burning wood can produce air quality issues, as in Interior Alaska, newer technologies are far cleaner and more efficient. Pushing for ever cleaner biomass heating systems could further expand its use in Alaska and ensure it is compatible with healthy air quality. Being flexible and finding ways to incorporate biomass heating for those who want it helps reduce costs, increase resiliency, and—when done hand-in-hand with education— can mean forest health and use of waste products such as sawdust or slash cut.

Question 4: *In your testimony you note "good housing is essential to a safe and healthy life." Can you describe how you view energy efficiency efforts holistically and the effect of building that into your approach?*

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A holistic approach to building means not just focusing on an energy efficient envelope and quality heating system, but ensuring the entire life cycle of the home—from its construction to everyday occupancy—promotes the health and well being of those living in it.

For many Alaskans, housing is more of a burden than a safe haven. The average rural resident spends $6,000 on energy per year, three times higher than the national average. In addition, many of Alaska's homes are overcrowded and underventilated, leading to respiratory disease, allergies, anxiety, and depression. Lowering energy costs is part of the solution. That is accomplished by building homes that are well insulated and airtight, and incorporate good building science to prevent moisture problems and reduce the risk of mold and structural damage.

But homes must also prioritize healthy indoor quality, which sometimes comes at the expense of energy efficiency. In a cold climate, where people spend so much time indoors and live in airtight homes, ventilation is absolutely critical. A healthy, balanced home will control humidity levels, get rid of indoor pollutants, prevent heating appliances from backdrafting, and provide occupants with fresh air.

Our "holistic approach" also includes culture and environment in the design and building process. CCHRC works closely with communities, seeking local input to ensure the finished product meets the cultural and environmental needs of the community. A home that matches the cultural needs of its occupants (for example, with a place for skinning animals or storing food) is just as important as the thermal performance of the walls. Making sure owners are involved in energy efficiency retrofits and construction of new buildings creates a sense of ownership that is key to success. It's also important that owners and occupants understand the home's technology, from the foundation to the fans. This holistic approach to design and construction ensures that a house is not only affordable but also a safe haven.

May 1, 2019

The Honorable John Hoeven
U.S. Senate
338 Russell Senate Office Building
Washington, DC 20510

The Honorable Joe Manchin
U.S. Senate
306 Hart Senate Office Building
Washington, DC 20510

Dear Senators Hoeven and Manchin,

We, the undersigned organizations, write in support of S. 1245, the "All-of-the-Above Federal Building Energy Conservation Act of 2019." This legislation would bring about much needed reform to federal energy policy and we commend your efforts.

The federal government is the largest energy consumer in the nation. U.S. taxpayers spend $6 billion a year on energy for buildings alone. Yet the federal government does not currently have requirements to improve the efficiency of federal facilities – a gap in policy that results in higher energy costs and more government spending. S. 1245 takes concrete steps towards sensible energy management requirements that will also save taxpayer dollars. The legislation would:

- Enhance energy intensity reductions and encourage the use of up-to-date energy management systems.
- Allow flexibility in energy audits and commissioning and strengthen federal commissioning directives.
- Require energy managers to implement energy efficiency measures recommended in energy audits, should they be found cost-effective.

These efficiency measures would be paired with a repeal of Section 433 of the Energy Independence and Security Act of 2007, which instituted a phaseout of fossil fuel use in federal buildings – culminating in the prohibition of all fossil fuel use (including fossil fuels used for electric generation) by 2030. This measure is nearly impossible to implement, causing uncertainty for energy providers and federal facilities while inhibiting long-term innovation and growth, all at a significant cost to taxpayers. Furthermore, the fossil fuel ban works

against increased energy efficiency by discouraging and preventing the adoption of high-efficiency technologies such as combined heat and power systems.

We believe this legislation is a step forward towards a cohesive and functional federal energy efficiency policy that not only works for the federal government, but also does not waste taxpayer dollars. The legislation would ensure that energy managers for federal buildings have the flexibility to achieve maximum efficiency goals and to realize actual energy savings.

We applaud your efforts and thank you for your continued focus on enhancing energy efficiency.

Sincerely,

Alliance to Save Energy
Ameresco
American Gas Association
American Public Gas Association
American Public Power Association
Constellation New Energy, Inc.
Edison Electric Institute
Energy Systems Group
Federal Performance Contracting Coalition
Fuel Cell and Hydrogen Energy Association
Honeywell
Johnson Controls Inc.
Lockheed Martin
National Association of Energy Service Companies
National Rural Electric Cooperative Association
Noresco
Schneider Electric
Siemens Corporation USA
Southland Energy
Trane
United Technologies

cc: The Honorable Lisa Murkowski

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