KEEPING THE LIGHTS ON: STRATEGIES FOR GRID RESILIENCE AND RELIABILITY

HEARING

BEFORE THE

SELECT COMMITTEE ON THE CLIMATE CRISIS HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTEENTH CONGRESS

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ONE HUNDRED SEVENTEENTH CONGRESS

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KEEPING THE LIGHTS ON: STRATEGIES FOR GRID RESILIENCE AND RELIABILITY

TUESDAY, FEBRUARY 15, 2022

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON THE CLIMATE CRISIS,
Washington, DC.

The committee met, pursuant to call, at 2:30 p.m., via Zoom, Hon. Kathy Castor [chairwoman of the committee] presiding.

Present: Representatives Castor, Bonamici, Brownley, Huffman, McEachin, Levin, Casten, Neguse, Graves, Palmer, Carter, Miller, Armstrong, Crenshaw, and Gonzalez.

Ms. CASTOR. The committee will come to order.

Welcome, everyone, to the "Keeping the Lights on: Strategies for Grid Resilience and Reliability" hearing.

Without objection, the chair is authorized to declare a recess of the committee at any time.

As a reminder, members participating in a hearing remotely should be visible on camera throughout the hearing. As with in-person meetings, members are responsible for controlling their own microphones. Members can be muted by staff only to avoid inadvertent background noise.

And, as a reminder, statements, documents, or motions must be submitted to the electronic repository at SCCC.Repository@mail.house.gov.

Finally, members or witnesses experiencing any technical problems should inform the committee staff immediately.

And I want to thank you all for joining our remote hearing of the Select Committee on the Climate Crisis. Today, we will review how the bipartisan infrastructure law's policies and investments will help improve grid resilience and consider what additional climate and clean energy investments are needed to help strengthen America's electrical grid.

I will now recognize myself for 5 minutes for an opening statement.

As the climate crisis continues to threaten our communities, we cannot remain stuck in the past. The key to solving the climate crisis is electrifying our economy now, and the key to electrifying our economy is a strong and reliable grid, with all of the incredible innovations that were not even envisioned 20 years ago.

Strengthening the grid today increases the chances that we can keep the lights on tomorrow after extreme weather hits. A strong grid also will help us drive down the costs of disasters, avoid dis-

ruptions, and allow businesses to bounce back faster. And it can reduce the cost of energy year-round, as more Americans power their homes and cars with affordable clean energy made in the USA.

Strengthening the grid is also about saving lives. Just last summer, at least one in three Americans experienced a climate-fueled disaster, and in many cases the consequences were deadly. We all remember the destructive winter storm only 1 year ago that knocked out electricity in much of Texas and in other areas across the Southeast, leaving millions without power. Nearly 250 people died in the aftermath, and too many families were left without drinking water, without food or shelter, and stuck with astronomical energy bills.

And it is not just winter storms; the climate crisis is making wildfires, hurricanes, and heat waves more frequent. In 2018, California experienced the costliest and most destructive wildfire in its history. The Camp Fire destroyed more than 18,000 buildings and killed 85 people. It was a devastating reminder of how aging transmission equipment, coupled with climate fueled drought, exposed communities to unexpected risks.

And it was a devastating example of how climate change is expanding the number of harmful scenarios we need to prepare for, making it more challenging to safeguard the places we call home.

And that is why today we are focusing on how we strengthen the grid and lower costs for the American people. I am proud that President Biden's bipartisan infrastructure law made historic investments on this front, including $5 billion for grid hardening, another $5 billion to spur technologies that will improve grid reliability and resilience.

The infrastructure law also included $2.5 billion to help build new transmission lines, as well as $3 billion devoted to enhancing grid flexibility. And it made investments to help address the growing threat of wildfires, including $5 billion to bury power lines and build microgrids and more than $3 billion for hazardous fuel reduction, controlled burning, and community defense.

The innovative advances in grid-enhancing technologies are remarkable, and we must deploy them at a wide scale to benefit all Americans and help them save on their electric bills.

All of these investments provide a great foundation to strengthen our grid, but we cannot stop there. We need additional strategies to keep the climate crisis from getting worse and to unleash an economy powered by our own abundant and affordable renewable energy.

That includes enacting new tax credits for transmission and storage. It includes expanding tax credits for clean energy and electric vehicles. And it means investing in the Greenhouse Gas Reduction Fund, which will help us deploy resilient distributed energy equitably to communities across America.

Those are the things the House sent to the Senate in our Build Back Better Act, and we look forward to the Senate getting these critical investments across the finish line.

Before I introduce our witnesses, I also want to set the record straight. In the United States of America, we do not need to choose between energy that is affordable, reliable, or clean. It is not an either/or situation. We can have all three. We don't need to pick be-

tween lower costs or a reliable electric grid or clean air for our kids. Clean energy gives us the chance to have it all.

That is why the Biden administration and Democrats in Congress are taking steps to meet these challenges head-on. That includes work to develop a national strategy on critical minerals and recycling, which will help us secure the components that we need to expand clean energy nationwide. And it means doubling down on innovative tools, whether it is harnessing the advances in Artificial Intelligence or expanding the use of buildings to grid, and vehicles, to grid technologies.

That is what is great about innovation in America and our can-do spirit. Our aging electric grid needs major upgrades and expansion, and it is time to integrate the lower-cost clean technologies into the power system, to invest in adaptation and resilience, and to solve the climate crisis.

With that, I am happy to recognize the Ranking Member.

Mr. Graves, you are recognized for 5 minutes for an opening statement.

[The statement of Ms. Castor follows:]

Opening Statement of Chair Kathy Castor
Hearing on "Keeping the Lights On:
Strategies for Grid Resilience and Reliability"
Select Committee on the Climate Crisis
February 15, 2022

As prepared for delivery

As the climate crisis continues to threaten our communities, we cannot remain stuck in the past. The key to solving the climate crisis is electrifying our economy now—and the key to electrifying our economy is a strong and reliable grid with the incredible innovations that were not even envisioned twenty years ago. Strengthening the grid today increases the chances that we can keep the lights on tomorrow after extreme weather hits. A strong grid also will help drive down the costs of disasters, avoid disruptions, and allow businesses to bounce back faster. And it can reduce the costs of energy year-round, as more Americans power their homes and cars with affordable, clean electricity made in the USA.

Strengthening the grid is also about saving lives. Just last summer, at least one in three Americans experienced a climate disaster—and in many cases, the consequences were deadly. We all remember the destructive winter storm only one year ago that knocked out electricity in much of Texas and other areas across the Southeast, leaving millions without power. Nearly 250 people died in the aftermath—and too many families were left without drinking water, without food or shelter, or stuck with astronomical energy bills.

And it's not just winter storms; the climate crisis is making wildfires, hurricanes, and heat waves more frequent. In 2018, California experienced the costliest and most destructive wildfire in its history. The Camp Fire destroyed more than 18,000 buildings and killed 85 people. It was a devastating reminder of how aging transmission equipment, coupled with climate-fueled drought, expose communities to unexpected risks. And it was a devastating example of how climate change is expanding the number of harmful scenarios we need to prepare for, making it more challenging to safeguard the places we call home.

That's why today we're focusing on ways to strengthen the grid and lower costs for the American people. I'm proud that President Biden's bipartisan infrastructure law made historic investments on this front—including $5 billion for grid hardening and another $5 billion to spur technologies that will improve grid reliability and resilience. The Infrastructure Law included $2.5 billion to help build new transmission lines, as well as $3 billion devoted to enhancing grid flexibility. And it made investments to help address the growing threat of wildfires, including $5 billion for burying power lines and building microgrids, and more than $3 billion for hazardous fuel reduction, controlled burning, and community defense resources. The innovative

advances in grid-enhancing technologies are remarkable. And we must deploy them at a wide scale to benefit all Americans and help them save on electric bills.

All of these investments provide a great foundation to strengthen our grid. But we cannot stop there. We need additional strategies to keep the climate crisis from getting worse—and to unleash an economy powered by our own abundant and affordable renewable energy. That includes enacting new tax credits for transmission and storage. It includes expanding tax credits for clean energy and electric vehicles. And it means investing in the Greenhouse Gas Reduction Fund, which will help us deploy resilient distributed energy equitably to communities across the country. Those are all things that the House sent to the Senate in our Build Back Better Act. And we look forward to the Senate getting these critical investments past the finish line.

Before we introduce our witnesses, I want to set the record straight: in the United States of America, we don't need to choose between energy that's affordable, reliable, or clean. It's not an either/or situation. We can have all three. We don't need to pick between lower costs, a reliable electric grid, or clean air for our kids. Clean energy gives us the chance to have it all. That's why the Biden Administration and Democrats in Congress are taking steps to meet these challenges head on. That includes work to develop a national strategy on critical minerals and recycling, which will help us secure the components we need to expand clean energy nationwide. And it means doubling down on innovative tools, whether it's harnessing advances in Artificial Intelligence, or expanding the use of buildings-to-grid and vehicles-to-grid technologies.

That's what is great about innovation in America and our "can do" spirit. Our aging electric grid needs major upgrades and expansion. It's time to integrate lower-cost clean technologies into the power system, to invest in adaptation and resilience, and to solve the climate crisis.

Mr. GRAVES. Thank you, Madam Chair. Thank you.

And I want to thank the witnesses for joining us today.

Madam Chair, we certainly share the objective—and I think I speak for all members of the committee that we share the objective—of moving in a direction of improved access to energy, improved affordability to energy, and lower emissions from energy. I think we also agree that our energy needs to be sourced or supplied within the United States.

We have had witnesses come and testify before this committee and we have read expert reports that have found by some measure that we are going to have to triple—we are going to have to triple—investment in our electrical grid to meet growing demand.

And it is not just about investment in transmission, investment in the grid; it is investment in generation capacity as well.

Unfortunately, what we have seen over the last several months is we have seen energy policies that have not resulted in those outcomes. As a matter of fact, we have seen energy prices, depending on the type of energy and the area, increase anywhere from 24 to 54 percent. We have seen one in every five Americans say they can't even afford to pay their energy bill in full each month. This is forcing more Americans into energy poverty. We have seen one of the highest rates of emissions increases last year that we have seen in recent history. And so we are not achieving these objectives of energy affordability, energy access, or lower emissions.

And I think it is important that we look, for example, at my good friend Mr. Huffman's state of California and others as examples of where we can extract lessons learned.

We have seen examples where the State of California is choosing to shut down nuclear power plants and then the next day sending a letter asking for waivers on Clean Air Act emissions so they can emit more because they are going to go from a carbon-free generation capacity into using coal and natural gas.

We have seen a state with the least reliable grid in America—and this is the state that is leaning farthest forward in regard to trying to implement a climate strategy and forcing markets in directions of renewable energy where markets clearly aren't capable of sustaining them.

We see a state that is the most dependent state on importing energy, including, as we recently discussed last week, the state that is responsible for 50 percent of the energy coming out of the Amazon rainforest in Ecuador.

I mean, these are things that simply don't make sense.

Maybe we can go over to the Northeast—sorry, Mr. Huffman, I am going to pivot now—go over to the Northeast—I know you are going to get me back, but—go over to the Northeast, where we have seen repeatedly where in New England they have had to bring in liquefied natural gas from Russia to meet the energy demands.

It is amazing. There was a recent EIA report that says that "although oil-fired generators are infrequently used in New England, they play an important role in meeting electricity demand in the region during times of high demand and limited supply of alternative fuel sources such as natural gas."

It goes on to say that "cold weather and constraints on natural gas pipelines to New England can sometimes limit the availability of natural gas delivered to power plants during winter months. These constraints can increase the price of natural gas in the region."

Madam Chair, if we simply applied the electricity rates of my home state of Louisiana to the State of California, you would see a reduction in rates of almost 51 percent—51 percent. I am sure that the citizens of California would welcome that type of reduction.

We can't sit here and have rational discussions or move in the direction of rational policy where we are saying the same thing—energy access improvements, energy affordability improvements, lower emissions—whenever the facts that are being—or the words that are being thrown out there don't match the facts. The reality is, California has had some of the worst emissions growth in America.

We need to be learning from California, learning from New England, and even learning from the U.K., where they went and leaned too hard on wind energy, had a year without much wind, and saw spikes in natural gas prices in that country that is causing the lack of affordability and the lack of access.

Madam Chair, the Biden administration has said energy demand is going to increase 50 percent between now and 2050, and, depending on developing or nondeveloping countries, you are going to see an increase in natural gas demand alone anywhere from 31 to 80 percent increase.

We need to have a strategy in the United States to meet these demands to ensure that our citizens aren't forced into energy poverty as a result of these policies that lack evidence, that are actually ignoring evidence to the contrary.

And a perfect example is the Biden administration choosing to shut down the Twin Metals mine that is projected to serve approxi-

mately 70 percent of the rare-earth and critical mineral needs in the United States. They just—they don't match reality.

So, Madam Chair, I look forward to hearing from some of our witnesses today and I look forward to being able to ask questions, but making sure that we are heading down a path that is actually logical and based on the evidence that has been presented to us.

I yield back.

Ms. CASTOR. And, without objection, members who wish to enter an opening statement into the record have—everyone has 5 business days to do so.

[The information follows:]

Statement for the Record
Rep. Veronica Escobar
Hearing on "Keeping the Lights On:
Strategies for Grid Resilience and Reliability"
Select Committee on the Climate Crisis
February 15, 2022

Thank you, Madam Chair, and thank you to our witnesses. I represent the safe and secure border city of El Paso, Texas. Last year's Texas winter storm stemmed from extreme weather and the lack of electric grid investments like winterization of energy infrastructure. Those planning failures caused millions of Texans to lose power, and many lives were unfortunately lost. However, my district was not affected by Winter Storm Uri due to El Paso being part of the Western power grid. Throughout the years our local electric utility company has made winterization investments to ensure El Pasoan's do not suffer from major power outages.

I would like to include as part of the record a February 2022 New York Times guest essay by University of Texas Professor Michael Webber titled 'When Will Texas Emerge from the Dark?' which explains that El Paso survived the Texas Freeze much better than many other parts of the state because of its investments in winterization of its equipment and its connection to the Western grid (https://www.nytimes.com/2022/02/15/opinion/texas-electricity-grid.html?smid=tw-share).

I join many of my colleagues who are local Texas elected officials in urging the state of Texas to expand interconnections to the Eastern and Western Grids.

Ms. CASTOR. Now I would like to welcome our witnesses. We will hear from leading industry experts regarding how the bipartisan infrastructure law and additional clean energy investments can help us increase the resilience of our nation's grid, the whole grid infrastructure, especially as we move towards the clean energy economy.

First, I will recognize Congresswoman Brownley to introduce Nancy Sutley.

Ms. BROWNLEY. Thank you, Madam Chair, for this honor. I appreciate it very much.

It is a pleasure to introduce Ms. Nancy Sutley, who currently serves as the Senior Assistant General Manager of External and Regulatory Affairs and the Chief Sustainability Officer for the Los Angeles Department of Water and Power.

In her role, Ms. Sutley oversees conservation, regulatory, and sustainability efforts for the largest municipal utility in the United States, serving 4 million residents. Not a better witness for us today.

I have known Ms. Sutley for many years, and our work together dates back to my time in the California State Assembly, when Ms. Sutley served as a board member for the Metropolitan Water District of Southern California and as Deputy Mayor of the City of Los Angeles for Energy and Environment.

Our work together continued when Ms. Sutley was appointed to lead President Obama's Council on Environmental Quality. Under her leadership, CEQ played a central role in shepherding the Obama administration's signature environmental projects, and she was one of the chief architects of President Obama's Climate Action Plan.

Ms. Sutley has dedicated her career to public service and environmental protection and has long been recognized for her work as a climate leader as she has advocated for strong climate policies aimed at improving conservation, environmental regulation, decarbonization goals of the energy sector, and so much more.

Ms. Sutley is a forward-thinking leader in government and has extensive experience bringing together stakeholders from all sectors to shift to a more sustainable future.

Thank you, Nancy, for being here today to speak about your work. I look forward to hearing from you.

And I yield back, Madam Chair.

Ms. CASTOR. Thank you, Rep. Brownley.

And welcome, Ms. Sutley.

Next, Dr. Karen Wayland is the Chief Executive Officer of GridWise Alliance. She is an expert in energy and environmental policy and leads a diverse group of stakeholders supporting grid modernization.

During the Obama administration, Dr. Wayland oversaw the development of strategies for working with state and local governments at the Department of Energy. Dr. Wayland also previously served as Senior Advisor for Domestic Energy Policy to the Deputy Secretary of Energy.

Mr. Mark Mills is the Senior Fellow at the Manhattan Institute, Faculty Fellow at the McCormick School of Engineering and Applied Science, and Co-Director at the Institute of Manufacturing Science and Innovation at Northwestern University.

He is a former experimental physicist and engineer and provided science and technology policy counsel to private-sector firms, the Department of Energy, and the U.S. research laboratories. Mr. Mills previously served in the White House Science Office under President Reagan.

And Ms. Katherine Hamilton is the Chair of 38 North Solutions and Chair of the Global Future Council on Clean Electrification at the World Economic Forum. She provides public policy and business development services to clean energy companies and organizations.

Ms. Hamilton is an international clean energy policy expert and led several councils of the World Economic Forum. She previously led buildings research at the National Renewable Energy Laboratory and designed grids for Virginia Power.

Without objection, the witnesses' written statements will be made part of the record.

With that, Ms. Sutley, you are now recognized. You are first up to give a 5-minute presentation of your testimony. Welcome.

STATEMENTS OF THE HONORABLE NANCY SUTLEY, SENIOR ASSISTANT GENERAL MANAGER OF EXTERNAL AND REGULATORY AFFAIRS AND CHIEF SUSTAINABILITY OFFICER FOR THE LOS ANGELES DEPARTMENT OF WATER AND POWER; KAREN WAYLAND, PH.D., CHIEF EXECUTIVE OFFICER OF GRIDWISE ALLIANCE; MARK MILLS, SENIOR FELLOW AT THE MANHATTAN INSTITUTE, FACULTY FELLOW AT THE MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE, AND CO-DIRECTOR OF THE INSTITUTE ON MANUFACTURING SCIENCE AND INNOVATION AT NORTHWESTERN UNIVERSITY; AND KATHERINE HAMILTON, CHAIR OF 38 NORTH SOLUTIONS AND CHAIR OF THE GLOBAL FUTURE COUNCIL ON CLEAN ELECTRIFICATION AT THE WORLD ECONOMIC FORUM

STATEMENT OF THE HONORABLE NANCY SUTLEY

Ms. SUTLEY. Thank you very much.

And, first of all, thank you, Representative Brownley, for that kind introduction and for all that you do for the people of California and the United States.

Chair Castor and Ranking Member Graves and members of the committee, I am very honored to be here with you today.

As you have heard, Los Angeles Department of Water and Power is the nation's largest municipally owned utility. We serve the 4 million residents of Los Angeles, its businesses and visitors, including some of those who were in town for some big football game over the weekend. For more than 100 years, LADWP has provided the city of Los Angeles with reliable water and power service in a cost-effective and environmentally responsible manner.

LADWP's power system is vertically integrated with our own transmission and distribution system in a diverse mix of energy generation resources. Today's hearing topic is very important. A reliable and resilient electric grid is essential for a strong and vibrant Los Angeles, and we have a strong track record and invest significantly in our power infrastructure.

However, the impacts of climate change can affect the reliability of our grid. Los Angeles lives with the ever present threat of longer wildfire seasons, more extreme heat, and prolonged droughts.

The men and women of LADWP work every day to ensure our grid is reliable, resilient, and affordable. And even during a heat wave, we have enough electrical capacity to meet the highest demands. But sustained high temperatures strain electrical cables and distributing stations, and when it doesn't cool down at night during a heat wave, high nighttime temperatures further tax equipment.

Our wildfire mitigation efforts include system-hardening, vegetation management, operation protocols, and maintenance programs. But wildfires can potentially put power lines out of service for days or weeks.

To support Los Angeles's decarbonization goals, LADWP is transforming its electric grid to 100-percent clean energy. And, over the decades, we have expanded renewable energy and replaced coal with clean energy; upgraded our transmission; invested in energy storage, rooftop solar, energy-efficiency measures; and supported

electrification. And, as a result, we have cut our greenhouse gas emissions by more than half from our 1990 levels. And we have kept our power rates competitive. They are generally lower than other cities in California.

To understand the pathways to 100 percent clean energy for LADWP, the National Renewable Energy Laboratory completed its "LA100" study in March of 2021. And this study showed multiple pathways to achieve a 100 percent renewable energy grid while prioritizing reliability, equity, and affordable rates. And, in fact, it found that it was feasible to get there by 2035.

The 2035 carbon-free scenario increases renewable energy, energy storage, and anticipates more rooftop solar, energy efficiency, and demand management, investments in transmission and distribution infrastructure, and firm generation using a renewable fuel, such as green hydrogen.

We are making investments in clean energy. Some recent examples: The Red Cloud Wind Project in New Mexico began commercial operation in December of 2021. We are launching a new program to assist apartment dwellers to save energy and money. And the IPP Renewed Project will replace coal with green hydrogen, first as a mix with natural gas and then 100-percent green hydrogen.

Now, there are a number of things that the Federal Government can do to help us meet these goals.

Federal funding can leverage our investments and can accelerate technology development and deployment of low- or zero-carbon energy resources. An example: We are part of a cooperative called HyDeal which is trying to reduce the cost of green hydrogen. Money in the bipartisan infrastructure law around hydrogen and the hydrogen hubs at DOE can really help accelerate that goal.

The Federal Government can support the expansion of the nation's transmission grid. We see a need for transmission investment, including increasing local transmission capacity.

Federal investment in electric vehicle charging infrastructure will help meet the needs of the growing electric vehicle market, but we also know from the "LA100" study that high levels of electrification can help mitigate rate impacts.

Federal policies and investments to reduce wildfire risk can help us remain reliable and resilient.

Finally, tax credits have helped to spur the clean energy industry. Policies could allow tax-exempt utilities like LADWP to benefit directly from those renewable and clean energy tax incentives.

Thank you for inviting me today to share these thoughts, and I am happy to answer any questions. Thank you.

[The statement of Ms. Sutley follows:]

Statement of Nancy Sutley
Senior Assistant General Manager of External and Regulatory Affairs
Chief Sustainability Officer
Los Angeles Department of Water and Power
Before the House Select Committee on the Climate Crisis
Hearing on "Keeping the Lights On: Strategies for Grid Resilience and Reliability"
February 15, 2022

Chair Castor, Ranking Member Graves and Members of the Committee: I am Nancy Sutley, Senior Assistant General Manager of External and Regulatory Affairs

and Chief Sustainability Officer at the Los Angeles Department of Water and Power. I am grateful for this opportunity to appear before you at this important hearing, "Keeping the Lights On: Strategies for Grid Resilience and Reliability."

The Los Angeles Department of Water and Power (LADWP) is the nation's largest municipally-owned utility, with 10,454 megawatts of electric capacity and serving an average of 435 million gallons of water per day to the more than 4 million residents of Los Angeles, California, its businesses and visitors. For more than 100 years, LADWP has provided the City of Los Angeles with reliable water and power service in a cost-effective and environmentally responsible manner. With a workforce of more than 11,000 employees, LADWP is guided by a five-member Board of Water and Power Commissioners, appointed by the Mayor of Los Angeles and confirmed by the Los Angeles City Council.

LADWP's power system is a vertically integrated power generation, transmission and distribution system that spans five Western states and delivers electricity to more than 1.5 million residential and business customers. In Fiscal Year 2019–2020, we supplied more than 21,130 gigawatt hours (GWh) to our customers—businesses, industry and government agencies consumed about 62 percent of the electricity, while residents constituted 90 percent of total customers. LADWP's generation capacity is made up of a diverse mix of energy resources, including 37 percent renewable energy (solar, wind and geothermal) in 2020. LADWP also has about 4000 miles of overhead transmission circuits and over 100 miles of underground transmission circuits and, as its own balancing authority, operates its own transmission grid.

Today's topic of strategies for grid resilience and reliability is incredibly important to LADWP and Los Angeles. A reliable and resilient electric grid is essential for a strong and vibrant Los Angeles. LADWP's power reliability continues to beat national norms for both interruption frequency and duration indices, which are reported by most U.S. electric utilities. Through the Power System Reliability Program, we continue to invest significantly in our power infrastructure, replacing aging electrical equipment and upgrading undersized ones.

Impacts of a changing climate affect the reliability and resilience of LADWP's electric grid. As Los Angeles Mayor Eric Garcetti said when he appeared before this committee last summer, "we now live with the ever-present threat of longer wildfire seasons; with more days of extreme heat; with prolonged drought conditions". For example, in July 2018, Los Angeles experienced record-breaking heat, not only in the typically hotter San Fernando Valley, but temperatures in downtown Los Angeles reached 108 degrees. And in the summer of 2020, California experienced its worst heat wave in more than a decade. During that time, LADWP was able to provide surplus power to the California Independent System Operator to support the electrical grid in other parts of California. LADWP has had enough electrical generating capacity to meet its needs on the highest demand days, the Power Supply Reliability Program investments have strengthened the grid, and power system crews work around the clock to keep the power on but sustained heat waves drive soaring demand for electricity and strain on electrical cables and distributing stations. That can lead to power outages. When it does not cool down at night during a heatwave, higher nighttime temperatures can further tax equipment and potentially cause more or longer outages.

Los Angeles' grid is also threatened by more frequent and intense wildfires. Wildfires pose a significant threat to public safety—directly and also because of their impact on the electrical grid. Over the past several years, California has experienced its largest fire seasons on record and the fire danger is magnified by higher temperatures, high winds, drier conditions and drought. Wildfire can damage the electrical grid—potentially putting power lines out of service for days or weeks. For example, in 2019, the Saddleridge Fire burned in an area with three major transmission corridors that bring electricity into the Los Angeles basin, reducing power imports. Fortunately, temperatures were cool, electrical demand was low but LADWP came within 135 megawatts (MW) of shedding load. Like other California electric utilities, LADWP prepares and implements a wildfire mitigation plan which includes system hardening, vegetation management, operating protocols and maintenance programs.

While we work every day to ensure our electricity grid is reliable, resilient and affordable, LADWP is transforming its electric grid to 100 percent clean energy to support the City of Los Angeles' decarbonization goals. LADWP's strategy—to expand renewable energy, replace coal with clean energy, transform local generation, upgrade transmission, develop energy storage systems, invest in distributed energy resources like rooftop and other local solar, help our customers use electricity more efficiently and support the electrification of vehicles and buildings—is dramatically reducing our greenhouse gas emissions. By the end of 2019, LADWP reduced its

greenhouse gas emissions from electricity generation by approximately 56 percent below our 1990 levels, all while maintaining power rates that are competitive, and generally lower than in other cities in California. Through the remainder of this decade, Los Angeles' goals include providing an energy mix that is 80 percent renewable and 97 percent carbon—free resources by 2030 on the way to a 100 percent clean energy grid.

To understand the pathways to 100 percent clean energy for LADWP, the National Renewable Energy Laboratory completed its LADWP's 100 Percent Renewables (LA100) Study in March 2021. https://www.nrel.gov/analysis/los-angeles-100-percent-renewable-study.html This in-depth and sophisticated analysis studied various scenarios to achieve a 100 percent renewable energy grid while prioritizing reliability, equity and affordable rates for our customers. NREL's LA100 study showed multiple paths for LADWP to achieve a 100 percent renewable and carbon-free grid and by as early as 2035. Following the release of the LA100 Study, Los Angeles Mayor Garcetti and the City Council committed LADWP to achieve 100 percent carbon free energy by 2035. LADWP's zero carbon grid will also enable deep decarbonization and reduction in air pollution, including nitrogen oxides and fine particulate emissions coming from other sectors of the economy through electrification of end-uses such as transportation and buildings, improving the health of Angelenos.

This 2035 carbon-free scenario includes significant rapid increase in the deployment of renewable and zero—carbon resources and shows that wind and solar resources, enabled with energy storage, are fundamental to providing the majority of energy required to meet future load. There is a need to accelerate the construction of new transmission lines and investments in the distribution grid to support the growth in renewable energy and meet increases in energy demand. Customers will play an important role through equitably increasing rooftop solar, energy efficiency and demand management and through the electrification of transportation and buildings. In the Los Angeles basin, firm generation, using renewably derived fuels such as green hydrogen that can come on-line quickly but is likely to be used infrequently, will help maintain electric system reliability.

While we continue to develop the steps to meet the 100 percent carbon free power supply target by 2035, projects that support these goals are moving forward. For example, in December 2021, the Red Cloud Wind project in New Mexico went into service, increasing renewable energy by 6 percent for 2022. We are also launching the Comprehensive Multifamily Retrofit program for deep energy savings for residents living in multifamily units. We are moving forward with a number of needed transmission and distribution grid infrastructure upgrades in the Los Angeles basin. We are also partnering with the Los Angeles Department of Recreation and Parks on a grid resiliency project at the Green Meadows Recreation Center in South Los Angeles, providing solar panels, energy storage and electric vehicle chargers in a disadvantaged community.

Other key projects currently underway include transforming the Intermountain Power Project in Utah, the last remaining coal plant in LADWP's energy portfolio. With our partners in the Intermountain Power Agency, we are building a new state-of-the art combined-cycle generating system that will use green hydrogen as a fuel source. "IPP Renewed" will be capable of operating with a blend of natural gas and 30 percent green hydrogen when it starts operation in 2025 and 100 percent green hydrogen in the decades to come. It will also feature a seasonal renewable energy storage system using salt caverns for storage of green hydrogen and will utilize the existing high-voltage transmission line to carry renewable energy to the Los Angeles basin.

We are committed to achieving these decarbonization goals in an affordable, equitable and reliable way. There are a number of things that the federal government can do to help us in our efforts towards a reliable, resilient and clean grid in Los Angeles. First, federal funding can help leverage our investments towards a clean energy grid. Federal investments aimed at carbon reduction can accelerate technology development, deployment and help utilities like LADWP and others decarbonize at scale equitably. For example, LADWP is participating in HyDeal LA, a cooperative effort aimed at delivering green hydrogen at $1.50/kg by 2030. Other types of federal support, including the Department of Energy Loan Program Office loan authority can help bring innovative projects to market.

Furthermore, the federal government can accelerate renewable energy deployment by supporting the expansion of the nation's transmission grid. LADWP is a large transmission infrastructure owner, with transmission assets that span five western states. We see the need for additional transmission investment, including increasing local transmission capacity to integrate renewables and maintain resiliency. We also know from the LA100 study that high levels of electrification will provide additional

electricity sales that will help mitigate rate impacts. Federal investment in electric vehicle charging infrastructure could help us realize those benefits in addition to meeting the needs of the growing electric vehicle market.

Other federal policies can help utilities remain reliable and resilient by supporting efforts to reduce wildfire risk. LADWP has water and power infrastructure that goes through National Forests and Bureau of Land Management lands and we work closely with those agencies to ensure continued and safe operation of those important assets.

Federal renewable and clean energy tax credits incentivize the deployment of those technologies. However, as a public agency, LADWP cannot access those directly. The value of the tax credits may be reflected in, for example, the price in a power purchase agreement but not in projects we may build or own ourselves. Policies that would allow tax-exempt utilities like LADWP to benefit directly from those energy tax incentives can make them fairer and more effective.

Thank you for inviting me to share some thoughts about the critical issue of grid resilience and reliability.

Ms. CASTOR. Thank you, Ms. Sutley.

Next, Dr. Wayland, you are recognized for 5 minutes.

STATEMENT OF KAREN WAYLAND, PH.D.

Dr. WAYLAND. Thank you. Good afternoon, Chair Castor, Ranking Member Graves, and members of the committee. Thank you for convening this important discussion on the resilience and reliability of the nation's electric grid.

My name is Karen Wayland. I am the CEO of GridWise Alliance. Our members are industry stakeholders focused on accelerating innovation to deliver a secure, reliable, resilient, and affordable grid and support decarbonization of the U.S. economy.

GridWise members include utilities of all sizes and business models—regional transmission operators, grid equipment manufacturers and tech companies, research institutes, and others. For our members, especially our utilities, the resilience, reliability, and affordability of electricity is of paramount importance, and all are committed to a low-carbon power supply.

Let me start by saying that every utility in every state faces resilience challenges, from severe storms to drought, earthquakes, sea level rise, and geomagnetic pulses, each requiring different risk management practices. And cyber and physical attacks are a constant, increasing, and evolving threat to the electricity system.

GridWise member Hitachi Energy notes that "our grid is evolving to be more interconnected and operating closer to its limits, making the ability to ride through disruptive events like extreme weather more important than focusing just on avoiding disruption entirely."

They note, "Power systems should be able to fall back on locally available sources in case the transmission grid is not available. Even if local generation capacity is insufficient to cover local load completely, supplying critical infrastructures, such as water supply, hospitals, or telecommunication networks, would be essential at the minimum."

GridWise convened members representing over 40 percent of the U.S. electric customers to discuss grid resilience a few years ago in the face of large-scale disruptive events. Our report includes lessons from our members' real-world experience.

First, grid modernization technologies can prevent outages and decrease projected impacts.

Second, distributed generation technologies can enhance the resilience of the grid.

Third, information and communications technology infrastructures should be more resilient, reliable, and secure.

And then, fourth, emergency response planning processes can result in better deployment and coordination of human and grid equipment resources.

I would like to give you some examples of GridWise members' work to enhance grid resilience.

First, let's start off with Chair Castor, a utility in her state, FPL, Florida Power and Light. Following devastating hurricanes in 2004 and 2005, FPL invested significantly in grid hardening and preparedness and has since become a leader in the industry on resilience.

The 2017 Hurricane Irma was a stronger storm than Wilma in 2005, but, as a result of their investments, average customer outages were 60 percent less and days to full power restoration for all customers went from 18 days to 10 days. The faster restoration had broad societal and economic benefits, but the investments in resilience also had day to day reliability benefits.

Portland General Electric will mitigate wildfires, severe storm events, and growing load by adding weather stations and wildfire cameras, underground and high-voltage lines, adding smart protective relays, storage, and rebuilding substations, upgrading transmission lines, and creating resilience zones that will serve residents during potential outages during winter storms and wildfire season when power shutoffs may be necessary to prevent a catastrophic wildfire event. PGE's distribution automation investments alone have prevented millions of customer outage minutes since 2018.

The February 2021 freeze led Bandera Electric Cooperative in Texas to focus on behind-the-meter residential resources like solar storage, HVAC systems, pools, and other distributed energy resources as critical to grid resilience. BEC's new platform, Apolloware, now collects real time-data to provide visibility at the grid edge.

For example, during the freeze event, home power use was 500 percent higher and HVAC demand 620 percent higher than normal, but energy use varied by a factor of 21 times, meaning that some homes were more cold-sensitive and used more energy relative to other homes.

Apolloware also provided insights into how appliances behind the meter were using electricity and allowed BEC to notify customers to stop charging storage units to save energy.

In a filing to the Public Utility Commission of Texas, BEC's CEO concluded that "having behind the meter visibility would help ERCOT with better grid planning and, more importantly, better understanding of how to minimize blackouts through the development of an intelligent demand response program based on fleet-wide monitoring control of HVAC, water heaters, pool pump devices," and others.

Further, "we have the technology to operate an intelligent grid down to the appliance level, but we need energy-efficiency programs and demand response programs tied to market pricing to keep the loss of power voluntary. If these programs had been in place last February, [the CEO believes] . . . that voluntary load re-

ductions would have been adequate to keep the grid from rolling blackouts on a statewide basis."

The $11 billion in the bipartisan infrastructure law for resilience funding will allow utilities around the country to accelerate their resilience projects. GridWise Alliance thanks the committee for the opportunity to provide insights on the resilience of the nation's electricity system.

Thank you.

[The statement of Dr. Wayland follows:]

Testimony of

Karen G. Wayland, Ph.D.
Chief Executive Officer
GridWise Alliance

U.S. House of Representatives Select Committee on the Climate Crisis
"Keeping the Lights On: Strategies for Grid Resilience and Reliability"
February 15, 2022

Good afternoon, Chair Castor, Ranking Member Graves, and other members of the Select Committee. Thank you for the opportunity to appear before you today to participate in this important hearing on the resilience and reliability of the nation's electricity grid.

My name is Karen Wayland, and I am the CEO of GridWise Alliance. The GridWise Alliance leads a diverse membership of electricity industry stakeholders focused on accelerating innovation that delivers a secure, reliable, resilient, and affordable grid to support decarbonization of the U.S. economy. GridWise is unique in its focus on the electric grid's broader ecosystem, advocating the value of integrating technologies that modernize and transform the grid. We drive impactful change through our diverse membership of utilities, manufacturers, grid operators and researchers united in a common belief that the electric grid is the critical enabling infrastructure of a decarbonized economy.

The GridWise membership includes investor-owned utilities, municipal utilities, rural cooperative utilities, regional transmission operators, grid equipment manufacturers and technology companies, vendors, national laboratory and research institutions, and others. GridWise has been convening member companies that have been leading the transformation of the electricity industry since our founding in 2003. For our utility members, the resilience, reliability, and affordability of electricity is of paramount importance, and all are committed to a low-carbon power supply.

Threats to the Nation's Electricity System

The massive Texas power failure in February 2021 and wildfires in California have focused public attention on the electric grid [1] and emphasized the growing dependence of all sectors of the economy on reliable electricity. The Texas blackout exposed some market and regulatory issues unique to that state, and the scale of economic loss is related to the size of the nation's largest state over which those losses are projected, but increasingly severe weather threatens power grids across the country. There were a record 22 weather events in 2020 in which the costs of damage exceeded $1 billion,[2] and the last two decades have seen a 67% increase in major power outages from weather events (Texas ranks second behind Michigan in the number of major outages).[3] Five of the worst wildfires in US history occurred in the last four years.[4] The utility industry is also under increasing threats of disruption from cyberattacks from both state-actors, like Russia and non-state actors. And because our critical infrastructure systems are increasingly interdependent,

[1] GridWise Alliance uses the term "electricity system" to encompass the entire network of generation, transmission, distribution and consumer/end users of electricity, and "electric grid" to refer to the transmission and distribution system. Here, we use "electric grid" as it has been used in the popular press.

[2] National Oceanic and Atmospheric Administration. "Billion Dollar Climate and Weather Disasters: Time Series." https://www.ncdc.noaa.gov/billions/time-series, accessed March 22, 2021.

[3] Climate Central. "Power OFF: Extreme Weather and Power Outages." https://medialibrary.climatecentral.org/resources/power-outages, accessed March 22, 2021.

[4] New York Times. "These Changes Are Needed Amid Worsening Wildfires, Experts Say." https://www.nytimes.com/2020/09/10/climate/wildfires-climate-policy.html, accessed March 22, 2021.

power outages can lead to cascading failures that affect other systems like water treatment (as happened in Texas last month) or gasoline dispensing (as happened in New York following Superstorm Sandy).

We should use the Texas and California blackouts as drivers for conversations about enhancing grid resilience, but we should not lose sight of the ranges of threats that could disrupt power supply at the local, regional, or national level, or even globally, each requiring different risk management practices.

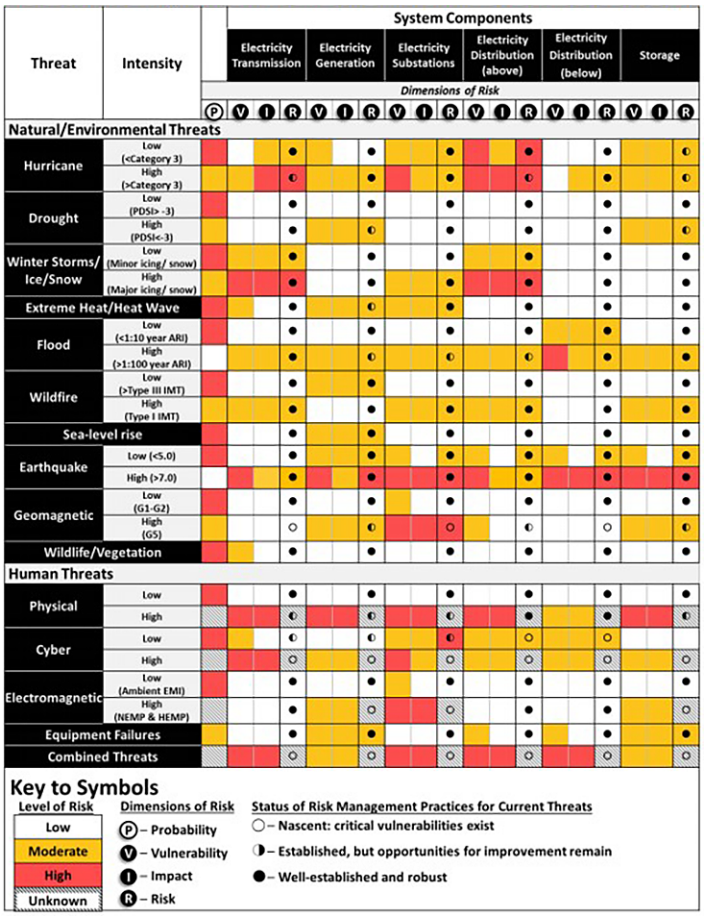
When I was at the U.S. Department of Energy (DOE), my policy team commissioned a report titled "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective"[5] as part of the second installment of the Quadrennial Energy Review.[6] The report identified a range of threats to the electricity sector that grid owners and operators, and federal, state, and local regulators and policy makers must consider while planning for and investing in grid resilience (Table 1). These threats range from extreme weather (hurricanes, floods, winter storms) to geological (earthquakes and geomagnetic pulses) to human-caused (cyber and physical attacks), with likelihood of occurrence varying from extremely low but with high impact to very likely with low- to-high impact. Similarly, the risks differ across the components of the electricity system. Planning for grid resilience requires risk management strategies for the range of hazards and probabilities that could impact grid infrastructure.

[5] Argonne National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective." https://www.energy.gov/policy/downloads/resilience-us-electricity-system-multi-hazard-perspective, accessed March 22, 2021.

[6] U.S. Department of Energy. "Quadrennial Energy Review—Transforming the Nation's Electricity System: Second Installment of the Quadrennial Energy Review." https://www.energy.gov/sites/prod/files/2017/02/f34/Quadrennial%20Energy%20Review--Second%20Installment%20%28Full%20Report%29.pdf, accessed March 22, 2021.

Table 1. Detailed Integrated Assessment of Risk and Resilience in the Electricity Sector.

Source: "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective



Caption: Assessment of risk and status of risk management practice are based on information in Section 4, published literature, and expert judgement (for statistically unknown threats). Table cells represent a qualitative assessment of risk by electric system component and threat. Some threats are divided into low or high intensity threats. Estimates of individual subcomponents of risk are presented for each system component and threat: probability refers to the frequency or likelihood of a threat occurring; vulnerabilty refers to the sensitivity of a system component to harm or damage; impact refers tothe potential severity of damage in terms of financial costs, affected coustomers, and/or health and safety. This table forms the basis for Table 7 in Section 5.2.

Achieving Resilience

The North American Electric Reliability Corporation (NERC), the organization that sets standards for the reliability of the nation's bulk power system, defines reliability as the ability "to meet the electricity needs of end-use customers even when unexpected equipment failures or other factors reduce the amount of available electricity."[7] Reliability metrics capture the frequency (System Average Interruption Frequency Index, or SAIFI) and duration (System Average Interruption Duration Index, or SAIDI) of power outages. These metrics are inadequate to describe the ability of the electricity system to withstand disruptions, minimize the consequences of disruptions that do occur, and quickly recover from those disruptions, which are the defining characteristics of system resilience. A resilient electricity system can also adapt through post-incident learning that feeds into planning and future response.

Enhancing the resilience of the electricity grid is a multi-pronged approach encompassing planning, operations, and technology. The "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective"[8] report identified three facets of building resilience:

- Resourcefulness: in practice this could be applied to the power transmission and distribution system by implementing a constant monitoring and optimized dispatching and/or load shedding to respond to anomalies. For example, if a critical transmission line is lost, power might still be delivered by temporarily overloading parallel/alternative routes and monitoring conductor temperature and time of overload conditions.
- Redundancy: over-engineering critical systems to be able to function, at least at a reduced level, in critical conditions.
- Restoration: coordination and integration among stakeholders of restoration efforts, plans optimized for a variety of scenarios to avoid the need of improvising a solution during critical conditions. Sharing best practices among different organizations (from local to global, nationwide) and practicing simulated emergencies should be mandated and coordinated at the national level. This sharing should include mutual assistance programs and their resources (personnel, equipment, parts) during the restoration phase. Electric utilities have a range of resilience options depending on the threats and hazards facing the region and specific infrastructure. Table 2 presents a list of options that utilities are pursuing to enhance system resilience with the goal of protecting the system, reducing the impact and areal extent of any damage, and accelerating restoration time.[9]

Utilities have a suite of options to enhance resilience of grid infrastructure (Table 2). Grid resilience measures aim to prevent disruptions to power supplies and reduce the severity of impacts and time to recovery in the event of power loss. Hardening of critical infrastructure for resilience may include undergrounding of some power lines, upgrading poles and towers to withstand high winds, and elevating substations above projected flood levels. Trees are the leading cause of power outages,[10] so utility vegetation management programs reduce flammable materials near power lines and remove trees at risk of falling. Utilities conduct practice drills and exercises throughout the year to prepare for disaster response. In the days leading up to an event, utilities will pre-stage crews and equipment in advance of events and may have plans to deenergize some facilities to prevent damage. Mutual assistance agreements with neighboring utilities help speed restoration efforts by deploying emergency response crews to disaster areas. But hardening and disaster planning alone are not sufficient to improve resilience.

New grid technologies that improve situational awareness and control of grid equipment can improve the reliability and resilience of the electricity system. Sensors can alert grid operators to localized disruptions, allowing more targeted re-

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[7] North American Electricity Reliability Corporation. "Frequently Asked Questions." https://www.nerc.com/AboutNERC/Documents/NERC%20FAQs%20AUG13.pdf, accessed March 22, 2021.

[8] Argonne National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective." https://www.energy.gov/policy/downloads/resilience-us-electricity-system-multi-hazard-perspective, accessed March 22, 2021.

[9] Argonne National Laboratory. "Front-Line Resilience Perspectives: The Electric Grid." https://www.osti.gov/biblio/1344876, accessed March 22, 2021.

[10] T&D World. "Plan for Better Vegetation Management in 2019." https://www.tdworld.com/vegetation-management/article/20971840/plan-for-better-vegetation-management-in-2019, accessed March 22, 2021.

sponse by line crews, and automated grid equipment can automatically sense and response to conditions in the field, including rerouting power around downed lines and self-healing damage. Remote sensing technologies allow utilities to obtain data from drones or NASA images to more effectively manage power line vegetation or assess damage. Advanced meter infrastructure (AMI), or "smart meters," help grid operators identify local outages and prioritize response crews and verify when power is restored, both reducing the time of outages and the cost of response by reducing "truck rolls" or repair visits.

GridWise member Siemens Energy describes some of its new technologies that utility and power generation customers are deploying to improve resilience:

- **Mobile Resiliency Flexible Extra High Voltage Large Power Transformers:** different from the traditional solutions in the industry, these Siemens Energy units can be deployed and energized extremely quickly (in benchmark times and much quicker than standard in the industry), are extremely flexible (can be used in a variety of configurations and voltage levels) and have large power (MVA) ratings to be used in large substations and power plants. While several utilities in the US have purchased these units to store in their equipment yards, Siemens Energy also operates a leasing program in which a Resiliency Generator Step Up (GSU) Large Power Transformer is owned by Siemens Energy in the US and leased to customers during contingency situations until they are able to source a permanent replacement transformer.[11] Note: that transformer is currently deployed at a power plant and other utilities have requested Siemens Energy deliver it to their sites as soon as it is again available.
- **Mobile Substations:** A mobile substation can act as a stand-by emergency grid restoration solution. It can be mobilized and set up within a couple of hours in the event of a grid failure, hence reducing the technical and financial impact of power outage.

[11] https://financialpost.com/pmn/press-releases-pmn/business-wire-news-releases-pmn/siemens-energy-installs-worlds-first-leased-rapid-response-transformers-allowing-a-large-generating-facility-to-return-to-service#:~:text=Siemens%20Energy%20is%20leasing%20the, their%20existing%2C%20conventional%20GSU%20transformer.

Table 2. Electric Utility Resilience Enhancement Options.
Source: Argonne National Laboratory, Front-Line Resilience Perspectives: The Electric Grid (ANL/GSS-16-2).

Resilience Enhancement Options	Definition	Example
Hardening	Physical changes that improve the durability and stability of specific pieces of infrastructure	Raising and sealing water-sensitive equipment
Security measures	Measures that detect and deter intrusions, attacks, and/or the effects of manmade disasters	In-depth security checks on all employees, badged entry and limited access areas, and surveillance and monitoring
Maintenance and general readiness	Routine efforts to minimize or prevent outages	Vegetation management and regular inspection and replacement of worn-out components
Modernization, control enhancements, and smart-grid technology	Technology and materials enhancements to create a more flexible and efficient grid	Integration of smart-grid technologies, such as smart meters and phasor measurement units
Diversified and integrated grid	Transitioning of the grid from a centralized system to a decentralized generation and distribution system	Integration of distributed generation sources, such as renewable energy sources and establishment of microgrids
Redundancy, backup equipment, and inventory management	Measures to prepare for potential disruptions to service	Maintenance of spare equipment inventory, priority agreements with suppliers, and maintenance of a supply of backup generators
Mutual aid programs	Agreements that encourage entities to plan ahead and put in place mechanisms to acquire emergency assistance during or after a disaster	Agreements between utilities to send aid or support after a disaster
Succession training, knowledge transfer, and workforce development	Planning for transfer of knowledge and skills from a large retiring workforce, to a smaller, younger workforce	Proactive efforts to create training and cross-training programs and succession plans
Business continuity and emergency action planning	A formal plan that addresses actions and procedures to maintain operations preceding an event	Components including employee awareness, training, and exercising
Models	Mathematical constructs that provide information on performance and/or disruptions to aide in decisionmaking	Probabilistic risk models to assist in predicting outage impacts after an event

- **Mobile SVC (STATCOM):** Siemens Energy developed a flexible, mobile substation for GridWise member Dominion Energy (Virginia) to help keep the grid stable to allow sufficient time to plan for renewables on its system. The substation technology also responds to any faults on the network within milliseconds.[12] Dominion notes that "The mobile STATCOM gives utilities the flexibility to develop short-term plans while successfully constructing a long-term solution. The ability to reduce outage contingencies and improve economic opportunity were the driving force."[13]
- **UPFC+ (Unified Power Flow Controller):** UPFC+ is used to effectively manage the transmission system and provide the stability and resilience through an extremely fast response with both series and parallel compensation to keep lines within the n-1 criterion and the electricity flowing. The UPFC can balance load flow in the AC grid, rapidly bypass overloaded line sections, provide reactive power and dynamic voltage control. It provides reactive power compensation, voltage control and active power load flow control in one unit.

[12] https://www.smart-energy.com/regional-news/north-america/dominion-energy-to-utilise-mobile-svc-statcom-tech/#:~:text=US%20utility%20Dominion%20Energy%20will,fast%20and%20controlled%20reactive%20power.
[13] https://www.tdworld.com/digital-innovations/statcom/article/21132983/dominion-energy-develops-mobile-statcom

Modern utility communication networks are critical for grid resilience. Modern networks improve operational speed and visibility for grid operators, and customer-facing communication channels provide information to customers on estimated time of power restoration as well as safety information and recommendations in the event of extended outages. Whether new utility applications provide grid situational awareness, automatically de-energize broken power lines before they hit the ground and start a wildfire, or coordinate small, distributed microgrids into a single virtual power plant, their operation will require utility private broadband networks—both wireless and wired. For example, Anterix, a GridWise member, recently announced the publication of a joint White Paper with Schweitzer Engineering Labs detailing the successful testing of a wildfire mitigation solution that when deployed as part of a wireless broadband network, can de-energize a falling power line before it hits the ground, removing its ability to spark a wildfire.

As decarbonization efforts lead to increased reliance upon distributed renewable energy resources and vastly greater electrification, the reliable, resilient, efficient and safe operation of the grid will be of growing importance in major sectors of the economy, from manufacturing to transportation. Utilities' broadband communications networks are a foundational element supporting decarbonization goals—they enable the smart grid capabilities utilities will rely on to reduce their greenhouse gas emissions. In the last year alone, a number of GridWise members have investigated, supported, or pursued the deployment of private wireless networks.

Distributed generation technologies such as microgrids and mobile generators can enhance the resilience of electric infrastructure serving critical loads, such as hospitals, water treatment facilities, and emergency shelters. Microgrids incorporate a generating source like a generator or solar panels with storage and energy management systems and can be "islanded" from the grid during power disruptions to provide back-up power. Mobile generators can provide temporary power to critical facilities, and utilities should identify locations where generators can be easily connected to the grid during emergency planning processes. Rooftop solar and storage systems can provide backup power to homes during short outages. Aggregated distributed energy resources can contribute power to meet load during extreme heat or cold events and mitigate disruptions associated with distribution or transmission line failure or loss of generation units.

GridWise member Hitachi Energy notes that our power systems are evolving to be more interconnected and operating closer to their limits, making the ability to ride through critical disruptive events like extreme weather more important than focusing instead on avoiding disruptions entirely: "Power systems should be able to fall back in a mode using locally available sources in case the transmission grid is not available. Even if local generation capacity is insufficient to cover local load completely, supply critical infrastructures, such as water supply, hospitals or telecommunications networks, would be essential as the minimum." [14] (Figure 1)

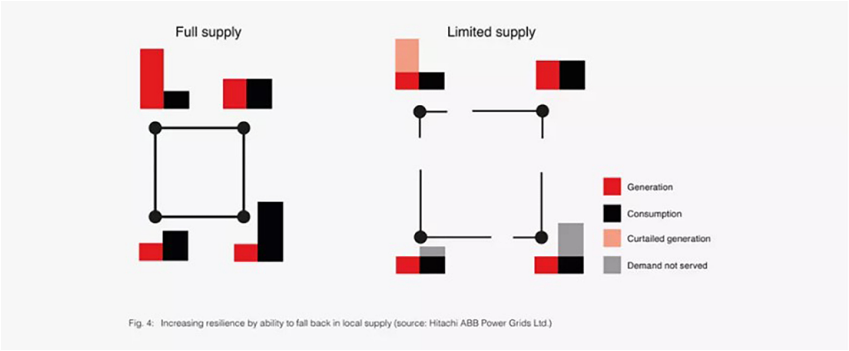

Figure 1. Increasing resilience by ability to fall back on local supply (Source: Hitachi Energy)

[14] https://www.hitachienergy.com/us/en/news/perspectives/2020/07/flexibility-and-resilience-our-aces-in-extraordinary-times

GridWise Alliance Member Investments in Grid Resilience

As noted above, the U.S. economy is increasingly dependent on electric power and this dependence is likely only to grow in coming years with growing electrification of the transportation, building and industrial sectors. The growing interdependency of lifeline systems and the electricity system increases the risk of a "cascading effect" during extreme events. As extreme weather events increase in frequency and strength, grid owners and operators are taking deliberate measures to ensure the system's reliability and flexibility support the Nation's needs. Utilities around the country are developing investment plans to deploy grid modernization technologies that can significantly enhance electric system reliability and resilience and prevent these cascading events. Several GridWise member utilities provided examples of their resilience investments to share with the Committee.

FPL (Florida)

The 2004 and 2005 hurricane seasons were one of the most extraordinary and challenging seasons on record for FPL and its customers. In 2004 alone, there were 15 storms and six major hurricanes. FPL was impacted by seven storms in its service territory, that resulted in significant customer outages and requiring extraordinary efforts to rebuild and restore the electric infrastructure which compelled FPL to re-examine and evaluate its infrastructure and policies.

Since 2006, FPL has been implementing Florida Public Service Commission-approved programs to strengthen its transmission and distribution ("T&D") infrastructure (See Figure 2). These programs include multiple storm hardening and storm preparedness programs, such as feeder hardening, replacing wood transmission structures, vegetation management, and pole inspections. As demonstrated by recent storm events, these ongoing storm hardening and storm preparedness programs have resulted in FPL's T&D electrical grid becoming more storm resilient, experiencing less infrastructure damage and reduced restoration times, as compared to non-hardened facilities. Specifically, Table 3 highlights the significant reduction in restoration times due to hardening the grid from Hurricane Wilma in 2005, and Hurricane Irma in 2017. Despite Hurricane Irma being a stronger storm, the average customer outage during Irma was over 60% less than Hurricane Wilma. FPL's hardened feeders have performed over 40% better than non-hardened feeders on day-to-day reliability not just storm events. The faster restoration during storm events results in positive economic impact to communities with customers getting back to normal operations sooner. FPL is an industry leader in the electric grid resiliency space and has shared best practices and strategies with other utilities across states.

These programs have also provided significant improvements in day-to-day reliability. When old conductors, equipment and connectors are replaced as part of feeder hardening, the system becomes more efficient and therefore improves line losses resulting in a positive economic and environmental benefits.

Additionally, as FPL President and CEO Eric Silagy stated late last year regarding climate change: *"Florida is a rapidly growing state on the front lines of climate change and our customers deserve bold, decisive, long-term actions as we continue building a more resilient and sustainable energy future all of us can depend on, including future generations."*

FPL Key Storm Hardening Initiatives

Feeder Hardening:

Feeders (main distribution lines) are the backbone and therefore a critical component of FPL's overhead distribution system. Since 2006, FPL has been hardening its distribution feeders to meet Extreme Wind Loading (EWL) as defined by NESC rule 250.C to existing and new feeders. This allows poles to withstand wind gusts in upward of 145 mph in many parts of our service area. The design loading impact to meet EWL usually requires some combination of stronger poles and shorter span lengths (distance between poles) to reduce the wind loading imposed on the conductors and cables.

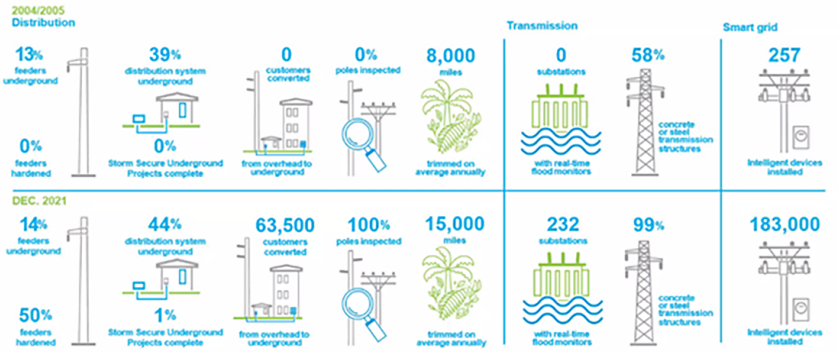

Figure 2. FPL investments in grid resilience.

Table 3. Improvement in restoration times from Hurricane Wilma to Hurricane Irma due to grid hardening.

	Hurricane Wilma (2005)	Hurricane Irma (2017)
Saffir-Simpson Scale	Category 3	Category 4
Fla. landfall max sustained winds	120 mph	130 mph
Cyclone Damage Potential Index	2.8	4.3
Customers outages avoided by AFS	N/A	~500K +
Customers affected	3.2 million (75%)	4.4 million (~90%)
Poles damaged	12400	2900
Transmission structures failed	100	5
Substations de-energized	241	92
Substations restored	5 days	1 day
50% of customers restored	5 days	1 day
100% of customers restored	**18 days**	**10 days**
Average customer outage	5.4 days	2.1 days

FPL's design strategy considered a philosophy of ***Prevention*** (EWL)/***Mitigation*** (minimizing damage) and ***Restoration*** (improving the efficiency of restoration in the event of failure). FPL implemented a system-wide Design Guidelines containing criteria which will apply EWL to the design and construction of all new overhead facilities, major planned work, relocation projects, as well as daily work activities. These guidelines primarily are associated with changes in pole class, pole type and desired span lengths. FPL began its efforts by hardening feeders serving Critical Infrastructure Facilities (CIF) such as hospitals, 911 Centers, special needs shelters, water treatment plants, police, and fire stations. In addition, FPL targeted feeders that served community needs such as gas stations, pharmacies, and grocery stores to help bring the community back to normalcy after a major storm event. FPL hardened over 125 highway crossings, that could otherwise impede traffic flow of support and emergency vehicles after a major storm and over 300 "01" switches (first pole out of a substation with a feeder switch). As of year-end 2021, nearly 2/3rd or 64% of FPL's feeders are either hardened or placed underground.

Distribution Pole Inspection:

FPL inspects all its distribution poles on an 8-year cycle or roughly 1/8th of its distribution poles annually. Inspections include a visual inspection, sound and bore, excavation and treatment where applicable. Strength calculations are also performed on wood poles to determine compliance with NESC requirements. The poles that are not suitable for continued service are designated for replacement or remediation.

Transmission Pole Inspection and Hardening:

FPL inspects its transmission circuits, substations, and other equipment on a six-year cycle. All of FPL's transmission structures are visually inspected from the

ground each year. FPL performs climbing or bucket truck inspections on all wood transmission structures on a six-year cycle and all steel and concrete structures on a ten-year cycle. Inspections for wood structures include an overall assessment of the condition of the structures, as well as other pole/structure components including the foundation, all attachments, insulators, guys, cross-braces, cross-arms, and bolts. If a wood transmission structure does not pass visual inspection, it is designated for replacement with a concrete or steel transmission structure. Ninety-nine percent of transmission structures are now concrete or steel with the plan to reach one hundred percent by 2022. One hundred percent of ceramic post insulators on square concrete poles were replaced, to avoid cascading events. FPL has started a multiyear program for strategically converting overhead river crossings to underground.

Undergrounding:

To promote undergrounding, FPL provides cost credits towards applicable local government sponsored overhead to underground conversions. Over 63,000 customers have been converted as part of this initiative.

Vegetation:

FPL's has a systemwide three-year average trim cycle for distribution feeders and six-year average for lateral circuits (fused tap lines). FPL's transmission system is inspected annually to prevent vegetation-related outages.

Substation Storm Surge/Flood Mitigation Program:

FPL installed flood resistant substation doors and hardened windows and louvers, as well as flood monitoring systems both inside the relay vault and outside for situational awareness. FPL also developed a process to deploy an AquaDam System to help protect against flooding.

Storm Secure Underground Program (SSUP): Lateral Undergrounding

In 2018, FPL began the SSUP pilot which targets certain overhead laterals that were impacted by recent storms and that have a history of vegetation-related outages and other reliability issues for conversion from overhead to underground. Objectives of the pilot include determining the most cost-effective ways to underground lateral (neighborhood) power lines and testing different design and construction methods. FPL has completed approximately six hundred SSUP projects through the end of 2021, with another six hundred more planned in 2022.

Smart Grid:

In addition to making FPL's electrical system more resilient, the utility has installed several self-healing smart switches that help during storm events and reduce the time it takes to restore power. Those include more than 7,000 Automated Feeder Switches (AFS), more than 95,000 Automated Lateral Switches (ALS), more than 40,000 Automated Transformer Switches (ATS) and approximately 40,000 Intelligent Sensors. Since 2011, over ten million customer interruptions have been avoided because of smart grid devices.

Portland General Electric (Oregon)

Wildfire Mitigation:

PGE has developed plans to help mitigate increasing risk of wildfires in our service territory due to climate change. Mitigation activities include installing a network of weather stations and wildfire cameras to increase our situational awareness and respond to potential wildfire incidents in a more timely manner. System hardening projects include targeted undergrounding of high voltage infrastructure and/or reconductoring overhead lines in high risk fire zones with covered (insulated) conductors. Other mitigations include installing smart faulted circuit indicators, intelligent reclosers, and deploying smart protective relays and settings to limit the arc energy during a system fault and hence lowering the potential of starting a fire. These targeted system upgrades are over the next 10 years with an investment of $80–$100 million/year.

Benefit calculations for resiliency have not yet been developed, however we expect significant reductions in Customer Minutes Interrupted (CMI) in the areas that are transitioned to underground or covered conductors.

Mt Hood Reliability:

Due to increasing wildfire risk and impacts from more severe storm events, PGE is developing plans to increase reliability and resiliency along our transmission and distribution system that serves customers along the Mt Hood corridor. Included in

this project is undergrounding our 57kV transmission system that is the energy source for the mountain and serves the City of Portland's Bull Run water and hydro generation facilities. The Bull Run reservoirs are the main water source to nearly 1 million residents in the Willamette valley and is located in the heavily treed forest on Mt Hood. The project aims to increase the resiliency of this water supply system and reduce the risk of a devastating wildfire in the protected area. Also included is developing a resiliency zone in the Welches downtown area that will serve residents during potential outages during winter storms and during wildfire season where a Public Safety Power Shutoff (PSPS) may be necessary to prevent a catastrophic wildfire event. This total project is expected to take 10 years to complete at an estimated cost of $400–$600 million dollars.

Willamette Valley Resiliency:

Due to increasing impacts from more severe storms, increasing load growth in the Willamette Valley, and aging assets, PGE is developing plans to increase reliability and resiliency on the transmission and distribution system in the Willamette Valley Area. Included in this project is the rebuild of six substations and the addition of two new transmission sources. As part of the rebuilds, five substations and their associated transmission lines are upgraded from 57 kV to 115 kV. To increase reliability and resiliency on the transmission and distributions systems, the upgraded substations are converted from simple bus to ring bus configurations, aging substation assets are replaced, direct buried feeders are replaced, and transmission lines are upgraded. This total project is expected to take 7 years at an estimated cost of $240 million dollars.

Energy Storage Microgrids:

PGE has developed two energy storage microgrids in our service territory to offer community resiliency benefits. Both projects leverage partnerships with customer investments in new solar resources paired up with utility investment in energy storage and microgrid controls. These projects were implemented with a PGE capital investment of $2.5 million.

Distribution Automation:

PGE has been implementing a Distribution Automation (DA) program for several years. This program installs intelligent devices on the distribution system to automatically switch around faulted sections of the system in order to restore customers quickly. PGE has spent at least $13 million since 2018 on its DA program, benefiting 134,000 customers. PGE deployed SCADA-integrated G&W Viper ST reclosers, Sentient MM3 and ZMI smart line monitors, S&C TripSaver II reclosers and SEL-751 feeder breaker protective relays. PGE estimates the TripSaver reclosers have prevented over 3 million customer outage minutes since 2019 and the G&W Viper ST reclosers prevented over 8 million customer outage minutes since 2018.

Bandera Electric Cooperative (Texas)

In February 2021, the ERCOT power grid collapsed, reflecting failures on several different levels. As a transmission-owning electric utility, Bandera Electric Cooperative (BEC) was forced into "rolling black-outs" to save the grid from complete collapse. Prior to the ERCOT-mandated outages, Bandera had over 1500 outage events between Feb 12-14, 2021. The lessons BEC learned from the February 2021 event was the need to understand what was going at the edge of the grid and behind-the-meter residential solar, energy storage, HVAC systems, and other distributed energy resources.

Having visibility into what is happening at the edge of the grid is critical to grid resilience. BEC developed an energy analytic platform called Apolloware that greatly improved grid resilience in 2022. Apolloware Control Module (ACM) installs on residential and commercial buildings where it monitors various appliance, solar panel power and inverter, and electric service circuits, providing granular real-time data on behind-the-meter energy consumption and generation. The ACM transmits this data to a secure Apolloware cloud using the local internet connection. Homeowners and authorized users can view this data from any device through the Apolloware mobile app or website. In February 2021, Bandera had over 400 service locations with Apolloware with another 200 units planned for deployment by the end of 2021.

Apolloware allowed BEC to analyze energy use at the appliance level after the 2021 freeze event and published the results in a paper entitled, "What was hap-

pening inside Texas homes during the February 2021 freeze?"[15] In this paper and a submission to the Public Utility Commission of Texas (PUCT, Docket 52373), BEC described the impact of energy efficiency on grid reliability and affordability. Average home power draw was almost 500% higher and average HVAC power demand 620% higher during the period of February 11-20 compared to February 1, 2021. However, the kWh/sqft of homes monitored by Apolloware varied by a factor of 21, meaning some homes were more cold-sensitive and used more energy the colder the outside temperatures relative to other homes. Apolloware also allowed BEC to gain insights into what appliances behind the meter were using electricity (Figure 3). BEC discovered that during the freeze event, home batteries were still being charged, so the utility was able to notify customers to stop charging to save energy.

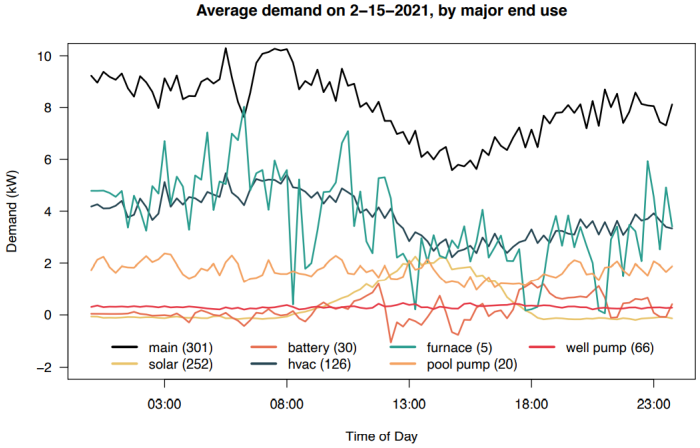

Figure 3. Average demand on 2-15-2021, by major end use within residential homes, as measured by Bandera Electric Cooperative.

While the weather in Texas on Feb 3–6 of 2022 was not as severe as 2021, Bandera experienced only 10 outages and was able to utilize energy analytics to provide better transparency of real time energy usage to its customers. In its submission to the PUCT in November 2021, BEC concluded that "Having granular individual data tied to substation, feeder and phase is an important aspect of understanding energy use tied to weather. . . Having behind the meter visibility and transparency would help ERCOT with better grid planning and more importantly better understanding of how to minimize black-outs through the development of an intelligent demand response program based on fleet wide monitoring and control of HVAC, Water Heaters and Pool pump devices ties to wholesale market prices. If this type of program had been in place during Winter Storm Uri the impacts would have been minimal. With the right pricing signals (utilities) could incentivize voluntary load reductions thereby avoiding MANDATORY rolling blackouts."

BEC's CEO, William Hetherington, concluded in the PUCT filing, "We have the technology to operate an intelligent grid down to the appliance level, but we need energy efficiency programs and individualized demand response programs that tie directly to market pricing to keep the loss of power voluntary. If these programs had been in place last February, I believe that Voluntary load reductions would have been adequate to keep the grid for rolling blackouts on a statewide basis."

Exelon (Multiple states)

Preparing for the impacts of climate change across all its jurisdictions, Exelon is investing to modernize its transmission and distribution grids to make them stronger and more resilient. Efforts include replacing poles to meet higher wind speeds, undergrounding select lines and expanding capacity to increase redundancies to meet critical load.

In New Jersey, as part of our broader strategic effort to better serve its customers and modernize the energy grid, Exelon (Atlantic City Electric) launched the Atlan-

[15] https://www.ideasmiths.net/wp-content/uploads/2022/02/BEC_TX_FREEZE_HOMES_APW_20220212_v2.pdf

tic-to-Ocean Counties Reliability Project, which includes rebuilding 15.1 miles of critical transmission line using stronger utility poles and modern equipment between Port Republic and Tuckerton. This transmission line serves more than 22,000 customers in the eastern portion of our service area in South Jersey and is critical to customer reliability in Atlantic, Burlington and Ocean counties. Construction began in 2020 and will be completed by Summer 2022.

In the District of Columbia, the DC Power Line Undergrounding initiative (DC PLUG) is a $500 million multi-year Pepco partnership and engagement with the District of Columbia government to strategically underground lines to secure the most vulnerable distribution power lines in the face of increasingly severe weather. In 2020, Pepco energized the first completed feeder, located in Ward 3, and initiated new projects in Wards 7 and 8. This initiative is expected to improve resiliency against major storms and to improve reliability by an estimated 95% on selected feeders.

ComEd in Illinois is the first utility in the U.S. to permanently install superconductor cable technology at a substation in Chicago's Irving Park neighborhood. Superconductor technology can support 200 times the current of standard copper wire, and allows electricity to be rerouted, creating a backup system that keeps electricity flowing in the event of a major power grid interruption.

Grid Resilience in the Infrastructure Investments and Jobs Act

The bipartisan Infrastructure Investment and Jobs Act (IIJA) passed by Congress in 2021 includes significant investments to make the grid smarter, more secure and more resilient. Federal funding for grid modernization will leverage private capital, accelerate grid modernization plans, and help de-risk state public utility commission decisions.

GridWise Alliance developed a set of investment priorities, "**Grid Investments for Economic Recovery,**"[16] for an infrastructure package. The policy framework included recommendations for over $50 billion in funding for programs across the federal government to deploy technologies that would increase grid flexibility, improve the integration of buildings and vehicles with the grid, address cybersecurity threats, create a domestic supply chain for critical grid equipment, modernize utility communication networks and help address the digital divide, and provide workforce training for digital, high tech grid jobs. The GridWise investment recommendations also include over $18 billion for mission critical public infrastructure resilience and emergency preparedness. Our recommendations also include funding for wildfire detection technologies.

The IIJA includes significant funding as recommended in the GridWise policy framework to defray the costs of resiliency, smart grid flexibility, cybersecurity and other emergency preparedness investments. Federal funding will leverage billions of dollars in private capital total for grid-integrated resiliency infrastructure.

According to the 2020 U.S. Energy and Employment Report (USEER),[17] energy jobs grew faster in 2019 than job growth as a whole, and the transmission, storage, and distribution sector, which employed over 700,000 people, was projected to grow 3.5% in 2020. This growth can be restored or accelerated by federal investment. Smart grid funding of $8 billion in the 2009 recovery bill created 80,000 jobs and accelerated the deployment of new technologies. The overall 2009 clean energy investments, including renewable generation, advanced vehicles, transit, equipment manufacturing, and job training, resulted in at least 720,000 new jobs.[18] The grid investments in IIJA will create significant jobs over the five years of funding and spur economic growth.

GridWise Alliance Grid Resilience Workshop Outcomes

With support from DOE, the GridWise Alliance brought together experts from utilities and grid equipment manufacturers and vendors for a workshop to develop recommendations for improving grid reliability and resilience in the face of very large-scale events (VLSE) like the Texas freeze of 2021, Superstorm Sandy in 2012, and the California wildfires of 2012 and 2020. The 20 utilities participating in the

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[16] GridWise Alliance. "Policy Framework for Grid Investments for Economic Recovery." https://gridwise.org/wp-content/uploads/2021/01/Policy-Framework-for-Stimulus-Investments-in-Grid-Modernization-FINAL-1.5.21-002.pdf, accessed March 22, 2021.

[17] National Association of State Energy Officials and Energy Futures Initiative. "U.S. Energy and Employment Jobs Report." https://www.usenergyjobs.org/, accessed March 22, 2021.

[18] White House Archives. "Impact of the American Recovery and Reinvestment Act on the Clean Energy Transformation." https://obamawhitehouse.archives.gov/blog/2010/04/21/impact-american-recovery-and-reinvestment-act-clean-energy-transformation, accessed March 22, 2021.

workshop represented over 40% of the nation's electric customers. The workshop resulted in a set of key recommendations detailed in "Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events."[19] Those recommendations are relevant for today's hearing about grid resilience, implementation of IIJA, and further actions Congress can take to improve grid resilience and reliability.

GRIDWISE LESSON LEARNED: GRID MODERNIZATION TECHNOLOGIES CAN PREVENT OUTAGES AND DECREASE PROJECTED IMPACTS

State and federal policy makers and electric utilities must accelerate the integration of existing grid modernization technologies to enhance grid resilience, reliability, safety, and security. Smart grid technologies can monitor and protect against disruption, optimize performance, and self-heal automatically. Improved situational awareness and control of grid equipment significantly enhance a utility's ability to reduce the impact of VLSEs and speed restoration efforts.

GRIDWISE LESSON LEARNED: DISTRIBUTED GENERATION TECHNOLOGIES SUCH AS MICROGRIDS AND MOBILE GENERATORS CAN ENHANCE THE RESILIENCE OF ELECTRIC INFRASTRUCTURE SERVING CRITICAL LOADS

A diversified and integrated grid can enhance resilience, with distributed energy resources able to provide back-up power to individual customers and flexibility for grid operations. Microgrids-distributed electric generation resources incorporating storage, load control, and energy management systems-are able to operate independently of the grid, although in normal operating conditions, they are integrated with the grid. On the customer side, distributed energy resources (DERs) like electric vehicles, rooftop solar, and storage can provide resilience to individual buildings; when DERs can be integrated with the grid and aggregated, they can provide services (e.g. power, voltage support, frequency regulation) that grid operators can harness to balance the grid during extreme events.

Microgrids

GridWise Alliance supports the expanded deployment of microgrids to provide power to critical infrastructure and isolated communities. Technical assistance should include identifying policy and regulatory issues that inhibit the management of microgrids and DERs during emergencies. Congress should ensure that as DOE implements its resilience grant programs that it engages stakeholders to explore potential solutions to regulatory and policy barriers associated with multi-customer microgrids. Some issues raised by GridWise resilience workshop participants include:

- Backup generators can run out of fuel; how will fuel supplies be obtained and ensured?
- Backup generators can be rendered inoperable due to flooding; are there ways in which to protect these assets from flooding?
- Renewable energy (e.g., rooftop solar) still requires an operational grid to supply local loads; how can the system supply these loads without grid power?
- Multi-customer microgrids have diverse operating requirements; who balances supply and demand on multi-customer microgrids?
- Some states prohibit third party sales of electricity; how will that affect the viability of multi-customer microgrids?
- Microgrids are becoming more prevalent; will utilities be allowed to own and/or manage microgrids?
- Regarding ways in which to integrate and tie multi-customer microgrids to the utility grid: what new rules, if any, are needed?

Distributed Energy Resources (DERs)

GridWise Alliance supports the expansion of DER deployment to meet resilience and climate goals and to meet changing customer expectations. To maximize the full value and potential of DERs for resilience and other goals, grid operators need a more flexible and agile grid architecture.[20] Advanced control and monitoring sys-

[19] GridWise Alliance. "Improving Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events." https://gridwise.org/superstorm-sandy-report/, accessed March 22, 2021.

[20] GridWise Alliance. "In an Accelerated Energy Transition, Can U.S. Utilities Fast-Track Transformation?" https://gridwise.org/wp-content/uploads/2019/12/Perspectives-on-a-Future-Distribution-System.pdf, accessed March 22, 2021.

tems that can dynamically respond to system changes will enable safe and reliable power restoration and support safe dispatch of DERs during VLSEs. GridWise recommends pairing investments to scale deployment of DERs on the customer side with investments in grid modernization to achieve continued power quality and reliability at the distribution level through the optimization and aggregation of local DERs.

Congress should ensure that DOE funding for resilience and grid flexibility can be used to continue the deployment of Advanced Metering Infrastructure (AMI, or "smart meters") and smart inverters.

- Smart meters significantly contribute to grid resilience by providing grid operators with granular information about the location of power outages and verification that power has been restored. Utilities use this information to prioritize dispatching repair crews and in communicating with customers, which reduces restoration costs and total outage time. Customers also experience benefits, including less lost productivity, food spoilage, and inconvenience, and reduced public health and safety hazards.[21] GridWise resilience workshop participants estimated that integrating AMI meters with restoration processes shaved 2-3 days off the time it would have taken to completely restore power after Superstorm Sandy, a 10-15% improvement in the speed of restoration.
- Smart inverters provide grid support functions, such as voltage regulation, frequency support and ride through capabilities.[22] In the event of a power disruption, a rooftop solar system will automatically shut off to prevent electricity to flow onto the power lines and potentially electrocute line workers. Smart inverters may include a circuit to allow customers to power their homes without sending electricity to the grid. Solar-battery combinations also allow customers to island their systems from the grid during power outages but have the added resilience benefit of providing power when the sun is not shining.

Buildings and Energy Efficiency

Buildings consume 76% of electricity generated in the United States.[23] IIJA includes significant funding for weatherization and energy efficiency improvements for federal, residential, and commercial buildings through updated building codes, funding for building retrofits, state energy grants, and other policy levers. Improving the efficiency of the nation's building stock will enhance resilience to energy disruptions in addition to saving energy. Well-insulated buildings reduce heating and cooling load during periods of high electricity demand associated with extreme weather and keep occupants more comfortable during power outages. Focusing resources for weatherization on underserved and low-income communities is critical to ensure that those populations do not suffer disproportionately during energy disruptions. IIJA funding will result in the weatherization and retrofitting of millions of public and private buildings across the country.

Congress should ensure that any programs to retrofit buildings encourages the installation of grid-connected Energy Management Systems (EMS) in addition to insulation and energy efficient windows and appliances, where possible. Grid-integrated buildings can be significant assets to the grid through load shifting, demand response, and aggregation of distributed generation. According to the National Association of State Energy Officials (NASEO), greater optimization of the significant energy demand and supply functions that buildings offer—on an automated basis—has far-reaching electricity policy and regulatory implications. The benefits include lower costs, enhanced resilience, reduced peak loads, enhanced energy efficiency and better integration of distributed energy resources.[24]

Funding should facilitate aggregation and management of building loads through grid-connected Energy Management Systems (EMS) and smart equipment/appliances within the building, and Advanced Meter Infrastructure (AMI) at the grid-

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[21] U.S. Department of Energy. "Smart Grid Investments Improve Grid Reliability, Resilience, and Storm Recovery." https://www.energy.gov/sites/prod/files/2014/12/f19/SG-ImprovesRestoration-Nov2014.pdf, accessed March 22, 2021.

[22] Interstate Renewable Energy Council. "Smart Inverters." https://irecusa.org/regulatory-reform/smart-inverters/, accessed March 22, 2021.

[23] U.S. Department of Energy. "Quadrennial Technology Review, Chapter 5: Increasing Efficiency of Building Systems and Technologies."
https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf, accessed March 22, 2021.

[24] National Association of State Energy Officials. "Grid-interactive Efficient Buildings: State Briefing Paper." https://naseo.org/data/sites/1/documents/publications/v3-Final-Updated-GEB-Doc-10-30.pdf, accessed March 22, 2021.

building interface. Though not the subject of today's hearing, electric vehicles (EV's) can also provide power and essential reliability services to the grid, and policies designed to increase deployment of EVs (Title IV) should also encourage vehicle-to-grid integration capabilities.

GRIDWISE LESSON LEARNED: INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) INFRASTRUCTURES SHOULD BE MORE RESILIENT, RELIABLE AND SECURE

Utilities' investments in operational fiber and wireless broadband communications network are essential for a modern grid, as noted previously. The legacy communications networks utilities have used for decades to monitor and control the state of the grid and stay in contact with utility workers and customers are inadequate for integrating new grid and customer technologies, which are driving increased communications traffic. These include "demand response systems, advanced metering infrastructure (AMI), distributed grid operations, grid automation, operational systems for managing power generation, outages and flows, two-way communications for consumer energy efficiency initiatives, transmission interconnectivity, and network security monitoring and reporting."[25] Utility communication systems can include fiber networks and private wireless networks must be integrated with legacy communications networks.

The broadband provisions in IIJA recognize that modern communications networks can also be leveraged to provide middle mile broadband and last mile internet service for end-use consumers. A modern, digital communications network is therefore the backbone of a modern grid and can provide significant resilience benefits, but it will have to be more reliable than other grid infrastructure in order to support a resilient grid that can monitor and react quickly to disruptions.

GRIDWISE LESSON LEARNED: ENHANCED EMERGENCY RESPONSE PLANNING PROCESSES CAN RESULT IN BETTER DEPLOYMENT AND COORDINATION OF HUMAN AND OTHER RESOURCES

Electric utilities, in conjunction with the appropriate federal and state agencies, continually develop predictive restoration plans at a regional level. These plans can be informed by enhanced weather and damage forecasting and advances in situational awareness and should use real-time validations to continually refine and update such plans. Mutual assistance agreements with neighboring utilities help speed restoration efforts by deploying emergency response crews to disaster areas. In the days leading up to an event, utilities will pre-stage crews and equipment in advance of events and may have plans to deenergize some facilities to prevent damage. Congress has raised specific concerns about the vulnerabilities of large power transformers (LPTs) given the growing threats to transformers and the long lead time in replacing them and required DOE to submit a plan to Congress for the establishment of a strategic transformer reserve.[26] The utility industry has a number of initiatives to create spare transformer reserves and stockpile parts and related equipment. The House of Representatives recently passed the COMPETES Act, which includes language to create a Strategic Transformer Reserve.

Planning for the response and restoration of energy disruptions is not the sole purview of the energy sector. VLSEs often affect multiple interdependent infrastructures (e.g., ICT and water) and several states and/or regions. Thus, planning for an event of this magnitude must involve coordination and collaboration at the federal, regional, state, and local levels, and between the public and private sectors, to address the breadth and inter-related nature of these potential impacts. Such efforts also must integrate people, technologies, and processes to maximize preparedness. State and federal emergency management offices should conduct annual joint simulations, drills, and related "pre-event" scenario planning efforts at the local, state, and regional levels to test their plans and strengthen their ability to collectively respond to VLSEs.

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[25] Power Grid International. "Challenges, Solutions in Utility Communications Networks." https://www.power-grid.com/smart-grid/challenges-solutions-in-utility-communications-networks/#gref, accessed March 22, 2021.

[26] U.S. Department of Energy. "Strategic Transformer Reserve: Report to Congress." https://www.energy.gov/sites/prod/files/2017/04/f34/Strategic%20Transformer%20Reserve%20Report%20-%20FINAL.pdf, accessed March 22, 2021.

In 2009, DOE provided $38 million in funding to states to update their energy assurance plans, and in 2010 provided $8 million for 43 cities to do the same.[27] (The funds came through the Infrastructure Security and Emergency Response division, or ISER, within the Office of Electricity; ISER is now within the Office of Cybersecurity, Energy Security, and Emergency Response, or CESER.) DOE also provided funding and technical assistance for a series of exercises to test the updated energy assurance plans. Energy assurance plans identify key public and private points of contact for the energy sector and emergency response units, formulate roles and responsibilities, lay out legal parameters, and identify critical infrastructure and potential hazards to each, as well as outline mitigation measures. Ideally these plans should be updated at least annually, but the reality is that most states and municipalities do not. In 2017, 12 states updated their energy assurance plans with some form of DOE assistance, and the National Association of State Energy Officials provided some technical assistance to three states in the process of updating their plans.[28] IIJA builds on this history with additional funding for state emergency planning.

CONCLUSION

GridWise Alliance thanks the Committee for the opportunity to discuss critical issues surrounding grid resilience and reliability. As Congress considers Build Back Better or other legislation related to the grid, we urge you to consider additional grid funding as recommended in the GridWise Alliance policy framework for grid investments.

GRIDWISE RECOMMENDATIONS

- **Increase funding for Smart Grid Investment Grant Program at DOE to enhance grid flexibility: $10 billion**

To balance electricity supply and demand, the grid must have system flexibility. Grid technologies like controls, sensors, storage, data analytics, advanced communications networks, and software-as-service can provide flexibility by improving visibility of the system for grid operators, helping to quickly rebalance system stability, and facilitating the integration and aggregation of distributed energy resources, including electric vehicles, to serve as assets to grid operations. Utilities' investments in operational fiber and wireless broadband communications network are essential for a modern grid. Utility communication systems can include fiber networks and private wireless networks that could also be leveraged to provide middle mile broadband and last mile internet service for end-use consumers.

If Congress creates significant new incentives for electric vehicles and charging infrastructure in Build Back Better, it must make commensurate investments in grid modernization to ensure the grid can serve as a platform for transportation electrification. Utilities will need to accommodate significantly increased load as well as provide customers with the tools to manage their charging, granular metering to generate billing to create rate plans and tariffs that reflect EV, upgraded communications and IT networks. Without parallel investments in grid modernization, utilities will face new challenges to grid reliability and stability at the local level driven by the forecasted electrification of fleets and residential vehicles. Also, rural cooperatives are less prepared for this type of engagement because historically EV adoption has been concentrated in urban and suburban neighborhoods where range anxiety is less of a concern.

- **Increase funding for DOE cybersecurity programs: $1.5 billion**

Cyberattacks are one of the most significant threats to the security of the grid. DOE funds platforms that can monitor attacks and share information across the utility industry and can also provide funding for the deployment of technologies that can prevent cyberattacks from damaging grid equipment. Unlike cyber funding from other federal agencies, DOE programs are designed to support utility cybersecurity efforts. Even with federal funding for monitoring platforms and technology, protecting the grid from cyberattacks is hampered by the lack of qualified cyber profes-

[27] U.S. Department of Energy. "Recovery Act: Local Energy Assurance Planning Initiatives." https://www.energy.gov/ceser/recovery-act-local-energy-assurance-planning-initiatives, accessed March 22, 2021.

[28] U.S. Department of Energy. "State, Local, Tribal and Territorial Energy Assurance: 2017 Year in Review." https://www.energy.gov/sites/default/files/2018/03/f50/SLTT%20Energy%20Assurance%202017%20Year%20in%20Review.pdf, accessed March 22, 2021.

sionals. The current cybersecurity workforce shortage in the United States alone is projected to be 498,480.[29]

- **$250 million to DOE Cybersecurity for Energy Delivery Systems (CEDS) for cybersecurity workforce development**
- **$250 million to DOE CEDS for cyber assessments and cyber threat monitoring for small and medium utilities**
- **$1 billion to DOE CESER for cybersecurity technology deployment**

- **Include the 48(c) manufacturing tax incentive: $8 billion**

The Section 48C Advanced Manufacturing Tax Credit in ARRA originally provided a 30 percent investment tax credit to 183 domestic clean energy manufacturing facilities valued at $2.3 billion and was extended to provide an additional $150 million in 2013. The tax credit helped build a U.S. manufacturing capacity and supported significant growth in U.S. exports. Qualifying manufactured clean energy products must include advanced grid technologies.

Ms. CASTOR. Thank you very much.

Next, Mr. Mills, you are recognized for 5 minutes.

STATEMENT OF MARK MILLS

Mr. MILLS. Thank you, Chairman Castor and Ranking Member Graves, for the opportunity to testify.

As you accurately pointed out in your introductory remarks and everyone knows, electricity infrastructures are, of course, critical to modern societies. And citizens and businesses expect and even take for granted that our grids will operate reliably and affordably.

So it is relevant to note some differences between America's grids today compared to a couple of decades ago. Overall grid reliability has actually been degrading even as the average consumer electricity costs have risen. The latter is up about, on average, 50 percent since the year 2000. And, of course, today, one big difference is that a significant share, almost 12 percent, of the nation's electricity is now supplied by solar and wind.

The fact is, wind and solar technologies are far cheaper and more useful than any time in history and, thus, have a substantial role in the nation's energy mix. But the critical issue now is how much nondispatchable wind and solar capacity can be added without further degrading grid reliability, because those two sources dominate current plans and proposals to expand energy supplies.

Grid reliability so far has been achieved by using power plants that can be dispatched when needed, at the time needed to meet expected peaks and unexpected peaks and for when outages occur from machine failures or from weather.

Going forward, there are three key realities relevant to grid reliability that emerge I would like to point out from the physics of energy systems that depend on batteries, the sun, and wind.

First, obviously, sunlight and wind vary, and quite radically, and are impossible to dispatch at will. The central issue isn't the daily or hourly variability that people talk about but seasonal variabilities. While the amount of sunlight or wind can be 50 percent less in off seasons, far more challenging are the days-long droughts, or so-called droughts, if you like, of wind when there is no wind or no sun at all.

Such episodes are surprisingly common, even if inherently unpredictable in terms of precisely when they occur, but they do occur.

[29] https://www.cpomagazine.com/cyber-security/cybersecurity-workforce-shortage-continues-to-grow/

The adage that it is always sunny or windy somewhere in the country is simply not true over decade time periods.

One solution to this reality would be to copy the German model, which has built essentially two grids—one using solar and wind, the other keeping conventional generation. That is a big reason German households, by the way, pay about 300 percent more for electricity than in America. But, as Europe discovered recently, when the inevitable wind droughts happen, the dual-grid option exposes consumers to radical energy price spikes. In fact, the dual-grid model creates those price spikes.

The other option, of course, is to use grid-scale batteries. These require extra generating capacity, again, roughly double, to both meet peak demand when the sun and wind are available and have surplus to simultaneously store in the batteries.

Which brings us to the second physics reality: Storing electricity is extremely difficult at grid scales. Some analysts propose that 12 hours of national backup would enable a nearly all solar/wind grid to keep America's lights on 99.97 percent of the time. However, that statistically and meteorologically means about a half day of no power anywhere in the country every few years or so. And the 12 hours of batteries would cost about a trillion dollars to build.

As for claims that batteries will get cheaper, last year the historical trend in battery price declines saw a dramatic slowdown, down just 6 percent. And prices are now forecast to rise this year. The reason is that mineral commodities make up 60 to 70 percent of the cost to build batteries. And, going forward, commodity inflation is likely to continue.

Which brings me to my third and last point anchored to the physics of energy: Batteries are very materials-intensive ways to store large amounts of energy. About 50 tons of batteries are needed to hold the amount of energy contained in 1 ton of oil, and then roughly 25,000 tons of materials have to be mined and processed to obtain the minerals needed to fabricate those 50 tons of batteries.

The IEA, among others, has studied the implications of this, and they have pointed out that these energy transition goals based on batteries, wind, and solar will require a 400 to 4,000 percent increase in the mining of a range of critical minerals—far more than all the global mines now produce or any plans for expansion.

Finally, it bears noting that China is the single largest source—by most accounts, nearly half—of all the critical materials for making batteries, as well as solar modules by the way. The United States is a minor player.

And aside from the geopolitical and trade considerations, it would require a World War II level of construction effort to build the quantities of wind, solar, and battery systems needed to replace America's conventional power plants by, say, 2040. The latter couldn't happen unless we cleared away regulatory delays, something else that is not now being proposed anywhere.

Thank you.

[The statement of Mr. Mills follows:]

Testimony of
Mark P. Mills
Senior Fellow, Manhattan Institute
Before
U.S. House Select Committee on the Climate Crisis
"Keeping the Lights On: Strategies for Grid Resilience and Reliability"

February 15, 2022

Good afternoon. Thank you for the opportunity to testify. I'm a Senior Fellow at the Manhattan Institute where I focus on science, technology, and energy issues. I am also a Faculty Fellow at the McCormick School of Engineering at Northwestern University where my focus is on supply chain systems and future manufacturing technologies. And, for the record, I'm a strategic partner in a venture fund focused on software in energy markets.

The focus of this hearing comes at an important time. Electricity systems are the most important infrastructures of a modern society. We use the euphemism of "keeping the lights on" because everyone knows that it's about far more than that. It's about water pumps and gasoline pumps as well as EV charging stations, and it's about both home furnaces and steel furnaces, refrigerators for vaccines hospitals and food in homes, and, critically, it's about the internet and Cloud networks that businesses of all kinds and sizes, not just citizens, increasingly depend on. The long-run electrification of society has been underway for over a century. and it is far from over.

Ensuring grid reliability and resilience requires dealing with the challenges of meeting both expected and unexpected peaks in demand that are a normal feature of society, while using electricity-producing machines that are episodically unavailable. Thus, the key issue for planners is in ensuring that power is always available to be "dispatched" when needed, and for the length of time needed. Today, the eight major grids that supply America have, collectively, hundreds of thousands of megawatts of 'excess' conventional generation—i.e., more than is needed most of the time—that can be dispatched when needed to fill gaps created by outages from machine failures or weather, or to meet unexpected peaks.

There are three important differences between America's grids today and in earlier decades. First, as EIA data shows and may in fact understate, overall grid reliability has been degrading; put inversely, outages have been increasing. Second, the average retail cost of electricity has been increasing for two decades, up 50% since the year 2000, after earlier declining for several decades. And third, there is now a significant share, almost 12%, of the primary electricity supply that *cannot* be dispatched when needed; that is of course the supply from wind and solar.

Setting aside state and federal policies intended to induce or require greater use of solar and wind, the fact is those technologies are now far cheaper and more useful than at any time in history and thus can now have a substantial role in the nation's energy mix. The key issue going forward is in how reliability—in particular dispatchability—can be maintained at prices consumers are willing to pay as more solar and wind systems are added.

Since sunlight and wind are, by definition, impossible to dispatch at will, the obvious critical issue is in how to fill gaps of unavailability. There are only two ways to do so: maintain or build additional conventional, dispatchable back-up capacity, or built lots of electricity storage. The amount and costs of the latter is almost entirely determined by the nature of nature.

The central challenge isn't so much the oft-noted diurnal variability of sunlight and wind. Rather, it's with two other features of nature. One is the seasonal variability of the wind and sun. The overfall amount of either can be 50%, or more, less in the off season, depending on geography. The other is the regular occurrence of days-long "droughts" of no wind or sun. Such multi-day weather events can be continent-wide (as Europe recently experienced). Meteorological history shows that while such episodes are inherently unpredictable in terms of exactly *when* they occur, it is entirely predictable that they *will* occur, and frequently, over the decades that grid equipment is built to operate. The adage that it's always sunny or windy somewhere in the country is simply not true over decadal periods. That reality, by the way, novates the benefit of building more transmission lines to use solar or wind installations elsewhere as backup.

Thus far, the primary means to ensure grid reliability as the solar/wind share rises could be called the German solution, which is, in effect, to build two grids; one based on solar and wind, and the other with conventional generation to serve, in effect, as the backup. The expense of such a solution is not born by the builders

of the solar and wind machines, but by ratepayers. That approach is one reason that the average German residential customer pays about 300% more for electricity than the average in America. However, as Europe has discovered during this past winter when an (inevitable) extended wind drought happened, the dual-grid option exposed consumers to radical fuel price spikes arising from the reality of supply chains. Converting a grid's fuel supply for conventional generation from long-term baseload contracts to episodically buying huge quantities, not only exposes consumers to huge price spikes, it creates those spikes.

The other option increasingly discussed, and even mandated in some states, is the use of grid-scale batteries. It's relevant to note that using solar and wind as a primary source of electricity—which some propose—means that grids will requires at least *twice* today's installed generating capacity. Far more than the normal peak generation would be needed to supply *both* peak demand when sunlight and wind are available, *and* to have surplus to simultaneous store in batteries. Such costs are typically not included in the calculus of aspirations for greater use of solar/wind on grids.

One can estimate the quantity of batteries required to, say, provide an average of 12 hours of backup for the nation. That's a quantity some analysts propose would be sufficient to allow an all solar/wind grid to keep America's lights on 99.97% of the time. That sounds good except that, statistically, mean on average, there'd be a few hours of zero power every year, or as a practical matter, nearly a half-day of no power, anywhere, every few years or so.

Nonetheless the nation is on track to build far more grid-scale batteries. And to be clear, those will be very useful for many short-term outages and other grid management and stability issues. But when it comes to using batteries to fill the solar/wind droughts that are inevitable, the 12-hour storage target for the nation would require spending over $1 trillion to build enough batteries. Even then, as the meteorological record shows, there will be frequent episodes in the foreseeable future when the entire nation would be lights-out if there isn't enough conventional generation available. For comparison, about $100 billion in capital—one tenth as much as the battery solution—is associated with the "excess" capacity on today's grid to ensure the lights are always on.

As for claims that batteries will soon become far cheaper; last year saw a dramatic slowdown in the decadal trend of battery price declines. Average lithium battery prices were down just 6% in 2021 and are forecast to *rise* this year. The reason is found in the fact that mineral commodities account for 60 to 70% of the cost to build a battery. Going forward, mineral commodity inflation will be fueled by the unprecedented increases in mineral demands to build energy systems.

The International Energy Agency, amongst others, has documented the magnitude of minerals that will be needed to accommodate massive increases in battery production for grids and, simultaneously, for electric cars. Combined with aspirations for greater use of solar and wind technologies—which also require far more minerals than conventional generation—the IEA estimates the world needs a 400% to 4,000% increase in mining of a range of critical energy minerals in the coming decade or two. Such an unprecedented increase in global mining is not now underway, nor planned—nor I might add, particularly encouraged by most policies.

Such surprising materials demand comes from physics realities. Batteries are an extremely challenging and expensive way to store large quantities of energy. It requires about 50 tons of batteries to hold the amount of energy contained in one ton of oil. And storing a ton of the later is very easy and cheap. Obtaining the minerals needed to fabricate the 50 tons of batteries requires mining and processing roughly 25 thousand tons of materials. This kind of disparity really adds up at grid scales.

Building enough grid-scale batteries for 12 hours of storage for the U.S. grid—never mind other grids in the world—would entail mining a quantity of materials equal to that needed to fabricate 100 centuries worth of batteries for all the world's billions of smartphones. This calculation doesn't count the minerals needed for the expanded use of electric cars, or the "energy minerals" needed to build the wind and solar machines.

Of course, it's reasonable to expect that different and even superior chemical concoctions will be discovered for future batteries. But it takes many years, even decades to make progress from discovery to industrial scales. For the usefully foreseeable future, and certainly in the timeframes contemplated in many policies, the technologies that exist today are what will be used to build systems.

It bears noting the geopolitical implications of all these energy minerals. China is not only the primary supplier of the world's polysilicon for solar modules, but it is also the single largest source—by most accounts nearly half—of most of the critical materials needed to build batteries. The United States is a minor player. The

rush to build battery assembly plants here in America is the equivalent of building cars here but importing all the gasoline.

Finally, building batteries, solar and wind machines at grid-scale is not fundamentally different than building anything else at such scales. All of it always entails massive uses of materials, construction equipment, time, capital and, critically, regulatory clearances and permits.

Building and installing enough hardware to replace all of America's conventional gas- and coal-fueled electric power plants by, say, 2040 would require a *continuous* grid construction program several hundred percent greater than occurred during any single peak year of grid construction over the past half-century. Such an endeavor would be, quite literally, an industrial effort comparable to a World War II level of mobilization. And it wouldn't be possible without clearing away regulatory delays, something that is not now being proposed anywhere.

Our increasingly digital economy, which everyone recognizes is ever more important to fueling economic growth, will require both more electricity and especially more reliability. While there is clearly a role on modern grids, and one greater than today, for solar, wind and battery systems, caution is in order when it comes ensuring the reliability of society's most critical infrastructure.

Ms. CASTOR. Thank you.

And, Ms. Hamilton, you are recognized for 5 minutes.

STATEMENT OF KATHERINE HAMILTON

Ms. HAMILTON. Thank you. Good afternoon. Thank you to Chair Castor, Ranking Member Graves, and the entire Select Committee for inviting me to testify.

I will explore what makes our grid and communities more resilient and how resilience has been partially incentivized in the Bipartisan Infrastructure Investment and Jobs Act but will be even further enhanced by final passage of the Build Back Better Act.

First, to briefly differentiate between reliability and resilience, since they are often used interchangeably, reliability is the characteristic of being there all the time—24/7, 365 days a year. Resilience is the ability to recover quickly from interruption.

Our electric grid has been designed for reliability: power plants, transmission lines, distribution systems that are available and operating all the time. And yet that system is becoming less reliable.

The drop in reliability can be tracked to weather related climate events—wildfires, ice storms, unprecedented flooding, extreme heat and cold—that have been increasing in frequency and level of damage.

Resilience and reliability are now linked inextricably and must be considered together.

In response to that need, utilities have been investing billions of dollars on equipment, technology, and updated systems to help withstand these extreme conditions. They have expanded vegetation management, line clearance, inspections, and system hardening and undergrounding.

And yet we have even more sophisticated technologies and applications at our disposal which are not being deployed at scale: transmission ties between regions, grid-enhancing technologies that allow for more visibility on those lines, and distributed energy resources which are all well-suited to providing resilience. Demand response and other customer-sited resources can provide crucial resilience services and be amplified through digitization. Nearly all of these technology solutions and applications are available today.

While the U.S. excels at technology innovation, policy is the crucial link and is foundational to filling gaps, crossing "valleys of

death," scaling technologies, catalyzing industries, and sending market signals to the private sector that can then put to use that innovation.

The infrastructure bill makes available significant funding for grid modernization, energy storage, and transmission, which are strong underpinnings for the clean energy transition and increased resilience of the grid. But it will be essential to pass in the Senate what the House passed in the Build Back Better Act, which complements the infrastructure bill's direct funding with market mechanisms to spur private sector certainty and investment in resilience.

A report from last month estimated that the cost of climate change in the U.S. could reach $14.5 trillion by 2070. As a recent Boston Globe headline read, "Compared with climate inaction, Build Back Better is downright cheap."

In the Build Back Better bill is the Greenhouse Gas Reduction Fund, which would be seeded by the government but sit outside as a nonprofit to provide creative finance solutions for zero-carbon technologies.

State level green banks, which are structured on the state level in the same way that a national fund would be set up, are already financing critical energy infrastructure to ensure grid resilience and support those most vulnerable to power outages. They are financing microgrids for local governments, clean backup power for affordable housing communities, and directly hardening structures against damaging weather caused by climate change.

Rebates for electrification are part of Build Back Better and are a pathway to engaging customers and providing access to clean and safe technologies for low- and middle-income communities. If electrification is planned and deployed correctly, reliability and resilience should increase.

One of the most important market tools is in the tax code. Access to tax credits will drive down the cost of energy storage of all types, opening up new markets in dozens of states and lowering the costs in states that already have storage targets.

The tax credit inclusion of interconnection costs will help smaller community solar projects penciled out for neighborhoods where rooftops are not always suited to solar or where consumers do not own their own homes.

The tax credit for microgrids will allow critical community services to operate when the grid goes down.

The tax credit for transmission would increase resilience in the supply side of the grid, spurring nearly $40 billion in private sector investment in inter-regional transmission and mitigating losses, such as those in the February 2021 polar vortex.

Other programs include the Department of Energy's loan program that will open up to additional sectors, like aviation and maritime, that can scale the clean energy transition in other parts of our economy.

But, of course, if we truly want to mitigate the climate crisis and deploy technologies that will be both reliable and resilient, we need to not only execute well on the infrastructure bill and pass the Build Back Better Act, but we need targeted appropriations funding, regulatory signals through the Environmental Protection

Agency, market structures through the Federal Energy Regulatory Commission.

In truth, all agencies in our government can take some responsibility within their missions for leading our nation to a safer, cleaner, more secure future from our climate crisis. And with our Federal Government aligned with the private sector's recognition that swift action must be taken on climate, there is far greater hope that we can reduce the impacts of this crisis on our nation.

Thank you for the opportunity to present this testimony, and I look forward to your questions.

[The statement of Ms. Hamilton follows:]

Testimony
of
Katherine Hamilton
before the
House of Representatives
Select Committee on the Climate Crisis
February 15, 2022

Good morning. My name is Katherine Hamilton. I am the Chair of the firm 38 North Solutions and serve as Chair of the World Economic Forum's Global Future Council on Clean Electrification. Thank you to Chair Castor, Ranking Member Graves, and the entire Select Committee for inviting me to testify before you today regarding clean energy resilience and reliability in the United States. I started my career designing grids at a utility for a decade and thus understand how our electric grid works and that both investment in that infrastructure as well as openness to technology innovation and customer engagement are necessary for the transition to a clean, resilient, and reliable grid. This testimony explores what will make our grid and communities more resilient and how resilience has been partially incentivized in the Infrastructure Investment and Jobs Act and will be even further enhanced by final passage of the Build Back Better Act.

I. Reliability and Resilience.

First, I would like to differentiate between reliability and resilience since they are often used interchangeably but are different in important ways. Reliability is the characteristic of being there all the time, 24/7, 365 days a year. Resilience, on the other hand, is the ability to recover quickly from interruption. Our electric grid has been designed for reliability—power plants, transmission lines, and distribution systems that are available and operating at all times—and yet, that system is becoming less reliable, leading to a downgrading of utilities by Fitch Ratings.[1] This drop in reliability can be tracked to weather-related climate events-wildfires, ice storms, unprecedented flooding, extreme heat and cold—that have been inexorably increasing in frequency and damage as a result of greenhouse gas emissions. Throughout the U.S. this physical risk from lack of resilience is compounded by the economic toll on our communities. Lawrence Berkeley National Laboratory studied the cost of these disasters—not just to the grid, but to the economy—and found that if the Bay Area in California lost power for 1–2 weeks, as much as $1–2 billion of economic output from downstream, non-utility activities would be lost in the region.[2] Importantly, resilience and reliability are now linked and must be considered together. And even more importantly, technology solutions exist today to address both while also reducing greenhouse gases that have led to the need for that resilience.

II. Technology Solutions.

In response to the need for more resilience, utilities have been examining their ability to ensure grid safety and climate resilience, with many investing billions of dollars on equipment, technology, and updated systems to help withstand extreme conditions. These comprehensive risk management programs include expanded vege-

[1] Bloomberg article here: https://www.bloomberg.com/news/articles/2021-11-08/u-s-power-grid-becoming-less-reliable-due-to-extreme-weather

[2] Lawrence Berkeley National Laboratory paper, page 24: https://eta-publications.lbl.gov/sites/default/files/hybrid_paper_final_22feb2021.pdf

tation management, line clearance, and system inspections as well as system hardening and undergrounding. When I led the GridWise Alliance, I testified before the Senate about the importance of smart grid technologies to economic growth and significant funding was deployed in the American Recovery and Reinvestment Act for technologies that could increase visibility on the electric grid. The co-benefit of this funding was that, thanks to smart grid technologies, today it would not take a year to determine that a branch falling on an electric line in Cleveland could bring down the entire Northeast grid.[3] A decade later, we have even more sophisticated technologies and applications at our disposal and yet many of those are not being deployed at scale. For example, transmission tie lines between regions can allow for seamless flow of electrons between areas that have power available and those that are experiencing outages. Had there been ties from Texas to other states or even between states like Alabama, Louisiana, Mississippi, and Arkansas, the recovery time from Winter Storm Uri could have been significantly reduced. When Hurricane Ida hit Louisiana in August of 2021, the lack of appropriate investment in transmission hardening and distributed resource solutions became even starker with widespread outages impacting over a million people and lasting for weeks.[4] Digital awareness combined with grid enhancing technologies could play an important role in grid resilience strategies by continuously monitoring overhead lines to ensure they are within safe operating limits and alerting operators when there are anomalies which pose risks to grid reliability or public safety.

Distributed energy resources are particularly well suited to providing resilience. In the U.S., experience in storms and other weather-related events has proven out that demand response and other consumer-sited resources can provide crucial resilience services[5] and research has only confirmed the importance of customer-side solutions to keeping grids operating during extreme temperature events.[6] During Winter Storm Uri, extreme cold increased demand for electricity by 8% while causing generation and transmission resources to become inoperable. Blake Shaffer, a professor of economics and public policy at the University of Calgary, told Marketplace Morning Report that, after Uri, so much of the conversation was about the supply side. "Our research sheds light on demand," Schaffer noted. "The sensitivity of demand to cold temperatures has risen a lot. Utilities and regulators need to consider demand when planning for future power system needs."[7] As far back as Hurricane Sandy, microgrid technology in New York and New Jersey enabled university campus facilities to continue operation in the face of massive power outages.[8] During heat waves in California, hundreds of energy storage facilities at office buildings in San Francisco were called to operate collectively as a "virtual power plant," reducing demand on an over-taxed grid. During the solar eclipse in 2017, over 750,000 programmable thermostats were lowered by their consumers to reduce demand by 700 MW as solar systems across the country were displaced in the temporary darkness.[9] Those thermostats alone provided as much grid service as seven gas peaker plants, often the most inefficient and emitting resources. All of these technology solutions and applications are available today and often simply need investment gaps filled or market signals put into place to make the grid more resilient, leading us to a discussion of federal policy.

III. Policy Solutions.

While the U.S. excels in technology innovation, public policy is foundational to filling gaps, crossing "valleys of death," scaling technologies, catalyzing industries, and sending market signals to the private sector that will then put to use that innovation. The bipartisan Infrastructure Investment and Jobs Act ("infrastructure bill") makes available significant funding for grid modernization, energy storage, and resilience. These grants will provide a strong underpinning for the clean energy transition and increase resilience of the grid. Last month the Administration launched

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[3] See article:
https://www.cleveland19.com/2020/08/14/years-later-blackout-that-impacted-million-people/

[4] https://www.reuters.com/business/environment/why-hurricane-ida-crippled-new-orleans-power-grid-2021-09-04/

[5] Multiple FERC filings from Advanced Energy Management discuss examples of resilience, one such example: https://aem-alliance.org/aema-files-reply-comments-in-resilience-proceeding/

[6] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3980881

[7] https://www.marketplace.org/shows/marketplace-morning-report/lessons-learned-from-the-power-outages-in-texas/

[8] Article on Princeton's microgrid can be found here:
https://www.princeton.edu/news/2014/10/23/two-years-after-hurricane-sandy-recognition-princetons-microgrid-still-surges

[9] See blog from Nest thermostats:
https://www.smartnest.io/solar-eclipse-meet-the-nest-thermostat/

the Building a Better Grid initiative which will execute on this legislation. As highlighted in this initiative, formula grants, competitive grants, and competitive awards would focus on enhancing grid resilience by upgrading transmission infrastructure. Investments in transmission infrastructure include increasing the capacity of existing lines, using advanced technologies to minimize transmission losses and maximize the value of existing lines, and building new long-distance, high voltage transmission lines. There is new funding for the deployment of technologies to enhance grid flexibility in the Smart Grid Investment Grant Program, which specifically calls out advanced transmission technologies and their ability to integrate renewable resources and create real-time situational awareness as a means of providing a more resilient grid. Other programs in the infrastructure bill that are important for resilience are electric vehicle charging infrastructure, energy efficiency, and appliance electrification, all of which allow for real-time management of customer load as a flexible grid resource.

In addition to the infrastructure bill, however, it will be crucial to pass in the Senate what the House passed in the climate portion of the Build Back Better Act ("BBB"). While the infrastructure bill will provide direct funding for innovative projects and manufacturing, the complementary BBB offers market mechanisms to spur private sector investment in resilient technologies and applications. The cost of damage from natural disasters in 2021 was $145 billion;[10] Hurricane Ida alone cost $75 billion.[11] A Deloitte report from last month estimated that the cost of climate change could cost the U.S. $14.5 trillion by 2070.[12] As a recent Boston Globe headline read: "Compared with climate inaction, Build Back Better is downright cheap."[13] [14]

One program that was passed several times in the House, including in the Build Back Better Act, is the Greenhouse Gas Reduction Fund, originally passed as the Clean Energy and Sustainability Accelerator. This non-profit entity would be seeded by the government but sit outside the government to provide creative investing solutions to scale zero carbon technology deployment. Many state-level green banks, which are structured on a state level the way a national level entity would be set up, are already financing critical energy infrastructure to ensure grid resilience and support those most vulnerable to power outages. This investment includes financing microgrids for local governments, and clean back-up power for affordable housing communities. In other cases, investments are made to directly harden structures against damaging weather caused by climate change. For example, the Solar and Energy Loan Fund in Florida provides financing not just for solar panels and efficiency measures, but also for roof hardening to make the home more resilient to hurricanes. This, in turn, lowers the home's insurance costs, with the savings used to pay back the loan.[15] Senate passage of this bill would enable investments such as these to be made in states and communities across the U.S. through the Greenhouse Gas Reduction Fund.

Rebates for electrification are part of the BBB and are essential to engaging customers and providing access to clean and safe electric technologies for low- and middle-income communities. If electrification is planned and deployed correctly, reliability and resilience should increase, not decrease. In fact, in a study released by the American Council for an Energy Efficient Economy,[16] the analysis showed an increase in reliability as a result of a combination of energy efficiency and electrification (which included heat pumps at a minimum, but in some cases heat pump water heaters, induction stoves, and electric vehicles).[17]

One of the most important market tools in the BBB is tax credits. Access to the Investment Tax Credit will be important to driving down the cost of energy storage of all types, opening up new markets in dozens of states and offsetting the cost of deployment in states like California, New York, Massachusetts, New Jersey, and Virginia that have robust energy storage targets in place. The investment tax credit

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[10] https://www.ncdc.noaa.gov/billions/summary-stats/US/2021

[11] https://www.ncdc.noaa.gov/billions/

[12] https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/deloitte-report-inaction-on-climate-change-could-cost-the-us-economy-trillions-by-2070.html

[13] https://www.bostonglobe.com/2021/12/21/science/compared-with-climate-inaction-build-back-better-is-downright-cheap/?p1=StaffPage

[14] These findings were summarized in an Evergreen Action article: https://www.evergreenaction.com/blog/why-we-cant-afford-not-to-pass-the-climate-investments-in-build-back-better

[15] https://solarenergyloanfund.org/loan/wind-resilience/

[16] https://www.aceee.org/sites/default/files/pdfs/programs_to_electrify_space_heating_brief_final_6-23-20.pdf

[17] See testimony at FERC: https://www.ferc.gov/media/panel-1-katherine-hamilton-world-economic-forum

inclusion of interconnection costs will enable smaller community solar projects to be cost-effectively deployed in neighborhoods where rooftops are not always suited to solar or where consumers do not own their homes. Opening the tax credit to microgrids will also directly impact resilience. Communities throughout the country are already installing microgrids to provide backup services in case of outage. Some examples include a microgrid at the Sonoma Valley Unified School District that will achieve bring more solar online, participate in wholesale markets, and charge electric school buses;[18] an Oakmont, California 1800 acre senior community of 3,204 homes, 24 businesses and a fire station, that has experienced nine public safety power shutoffs in the last four years has been approved to build a microgrid;[19] and the city of Gonzales in Salinas Valley has planned a $70 million microgrid to provide a business park with round-the-clock reliable power at cheaper than utility rates.[20] Projects like these and many more would benefit from this tax credit.

Opening the tax code to transmission would increase resilience on the supply side of the grid by incentivizing transmission technology deployment. Significant losses incurred during the Polar Vortex in February 2021—which claimed 246 lives[21] and caused $130 billion in damage in one week—could have been mitigated or avoided had there been more transmission ties to neighboring regions. A technology that would benefit from this credit is advanced high voltage direct current ("HVDC") technology, which strengthens reliability by controlling power dispatch, avoiding cascading outages and improving power quality by quickly adjusting voltage, frequency, and reactive power. Some developers are designing underground cable projects that can further protect them from extreme weather events, including storms, as well as flooding given the water impervious nature of the cable.

Other programs included in the BBB are the Department of Energy's loan program that will open up to additional sectors—such as aviation and maritime—to scale the clean energy transition in other parts of our economy. Funding for state and local governments and tribes will enable communities across the country to accelerate deployment of energy efficiency and electrification technologies. Many other programs are included in the BBB that will send those market signals to the private sector.

IV. Conclusion.

Of course, if we truly want to mitigate the climate crisis and deploy technologies that will be both reliable and resilient, we need to not only execute well on the infrastructure bill and pass the BBB Act, but we also need targeted Appropriations funding, regulatory signals through the Environmental Protection Agency, and market structures through the Federal Energy Regulatory Commission. In truth, all agencies in our government can take some responsibility within their missions for leading our nation to a safer, cleaner, more secure future from our climate crisis. With our federal government aligned with the private sector's recognition that swift action must be taken on climate, there is far greater hope that we can reduce the impacts of this crisis on our nation. Thank you for the opportunity to present this testimony; I look forward to your questions.

Ms. CASTOR. Well, thanks to all of our witnesses for your informative and insightful testimony.

I will recognize myself for the first 5 minutes for questions and start with a focus back on the bipartisan infrastructure law, the Infrastructure Investment and Jobs Act.

And I think what policymakers—what we were thinking about as we moved forward with the grid resilience piece is some win-win-win propositions. When you are strengthening the grid, you are making it more resilient to these climate fueled disasters, these more frequent and intense weather events; we want to lower the cost for consumers; we want to create jobs, good American jobs—when you are talking about the grid, these are all American jobs—and then reduce greenhouse gas pollution.

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[18] https://microgridknowledge.com/front-of-meter-microgrid-sonoma/

[19] https://microgridknowledge.com/oakmont-california-seniors-community-microgrid/

[20] https://www.greentechmedia.com/articles/read/california-town-tests-new-model-for-microgrids-as-a-service

[21] https://www.texastribune.org/2022/01/02/texas-winter-storm-final-death-toll-246/amp/

So, now, the DOE, the Department of Energy, will begin rolling out a lot of these moneys in partnership with communities and the private sector and other municipally owned like Ms. Sutley runs.

Ms. Hamilton, do you think we can do all of this and stay on the track for affordability and reliability and resilience? Do you agree that they are not mutually exclusive?

Ms. HAMILTON. Yes. Thank you for the question. They are absolutely not mutually exclusive. I absolutely agree with that.

One thing we do have to think about, though—and Mr. Graves mentioned this in his opening statement too—is that we do have to, like, plan for this. We have to think about, what are all the pieces of this that are going to work together, be the least-cost options, and keep prices down for customers?

So you look at the supply side and how many clean energy technologies are available on that side—from solar and wind certainly, but also hydropower, nuclear, geothermal.

And then you look at the demand side, which is all the customers, right? So doing demand response, energy efficiency—which is the cheapest form of energy—and rooftop solar, battery storage, all these technologies on the demand side that the customer can bring.

And then the connective tissue. So you think about energy storage, you think about transmission and all the technologies that enhance transmission to work better, and then all the distribution technologies as well. All of these can be intertwined and allowed to work in real time using digitization.

So I think it is absolutely possible to do it all. And we have the technologies today. And I will tell you, I work with dozens of companies that want to invest and come and work with the government, partner with the government, to make sure that we can do this and transition.

Ms. CASTOR. Well, thank you.

And, Ms. Sutley, your utility, one of the largest municipally owned in the country, you have set a 100 percent clean energy goal by 2035.

How are you going to ensure that consumers are protected and yet you build in clean energy resources over time? What is your plan?

Ms. SUTLEY. Thank you, Chair Castor, for the question.

Well, we absolutely take it as our responsibility to ensure that this transition happens in a way that protects our customers, and we work very hard to make sure that that is happening.

We worked with the National Renewable Energy Laboratory to analyze scenarios that would get us to 100 percent clean energy. And it was really informed by a stakeholder group of businesses and community leaders and members of the community who helped us to kind of focus on the priorities for the kinds of investments that will help Los Angeles meet its goals and continue to flourish.

And sort of as a follow on, we started a process around equity strategies to make sure that all communities in Los Angeles see the benefit of this transformation.

But I would say that, you know, we have been meeting our financial targets. We have been, you know, managing our rates to try to protect our consumers. We also offer a lot of programs that help

our customers save energy and save money while helping us to manage the grid better.

And one of the things that we found in the "LA100" study was that the electrification of transportation and of buildings can really help to manage costs by expanding the sales of electricity in helping us to manage costs.

So this is first and foremost in our minds, to make sure that we do this in a way that protects Los Angeles's economy, creates jobs, and serves all of our communities.

Ms. CASTOR. Great.

Okay. Next, we will go to Mrs. Miller.

You are recognized for 5 minutes.

Mrs. MILLER. Thank you, Chair Castor and Ranking Member Graves.

And thank you to all the witnesses for being here today.

Grid resilience is one of the most important aspects of our national energy strategy. And, luckily, the United States has recently proven that it does not need to depend upon adversarial regimes to provide power to our constituents, due to the boom in American produced energy over the last several decades.

Under President Trump, America became a net energy exporter for the first time in a generation, selling our crude oil, natural gas, and coal all over the world, while providing everything we needed here at home.

Unfortunately, this progress is under siege by radical activists who are pressuring the Biden administration to shut down American energy jobs and leave behind production focused communities.

Look no further than President Biden nominating Sarah Bloom Raskin to serve as Vice Chair for Supervision at the Board of Governors of the Federal Reserve System. Ms. Raskin is an anti-American energy activist whose vision for the Federal Reserve is to block or discourage traditional energy companies from accessing capital markets in the American banking system.

Without the ability to finance costly upgrades, traditional energy companies will not be able to employ the future of carbon capture technology, leaving millions of Americans without jobs and the rest of our country reliant on either foreign imports from Russia and the Middle East or untested renewable energy that will never be able to supply the power that Americans have become accustomed to—all the while, still relying on China to source most renewable technologies.

We need smart policies to protect American energy producing communities and tackle the real problem: cutting carbon emissions. This won't be done by the Federal Government picking winners and losers but, instead, through an all-of-the-above energy strategy where we use American ingenuity and effective government incentives, not decades-long subsidies and reliance on foreign competitors.

Mr. Mills, in your testimony, you mentioned how essential it is for our energy infrastructure to be able to meet both expected and unexpected peaks in demand. Could you expand on what the scale of such an effort would look like for our country to fully rely on wind and solar technology?

Mr. MILLS. Thank you, Congresswoman Miller. It is an interesting problem, the scale problem.

I think everyone agrees the grid is critical and needs to be reliable. The scale of America's grids—and there is not one grid, as everyone knows—is really daunting to think in terms of supplying electricity from storage of any form, in terms of storing electricity directly.

If one were to calculate the quantity of minerals needed to produce enough batteries for the 12 hours I mentioned—and 12 hours is a typical number offered for grid-scale storage for the United States. And, today, just as a calibration point, the country has about 1 minute's worth of grid-scale electricity in grid-scale batteries stored at any given time. So we are, you know, many thousandths of a percent away from getting to 12 hours.

To get there would require mining more minerals that are now mined for all other purposes in the world for those batteries. There simply aren't enough mines yet. It doesn't mean we couldn't build the mines somewhere, but no one is proposing, really, to build the mines here.

Congress has ordered and administrations have looked at critical mineral dependencies now for roughly 60 years. This is not a new subject. The United States is 100 percent dependent on 17 minerals; imports more than half of another two dozen minerals. We are hostile to mineral expansion, mineral processing, and the related manufacturing in the United States. It is just a fact of the nature of the business for decades.

It is sort of naive to think that we are going to expand that kind of industry without radically increasing imports. In effect, building battery assembly plants here, bridge storage or for cars, is equivalent of building cars here and importing 100 percent of the gasoline.

You know, critical energy minerals are at the heart of the challenge that the IEA has pointed out. I am not the first to point this out. And it is a challenge that is not being taken up. And, in fact, the IEA's latest paper, buried on about page 20 of its sort of victory lap on the expansion of wind, solar, and electric cars in the last year, points out that the world is not now—no country is now expanding its mineral production capability.

Those that do have it, of course, as I mentioned, is China, the biggest processors; Africa; South America. My homeland, Canada, produces lots of minerals and is probably happy to produce more. But nobody is planning the scales needed.

Mrs. MILLER. Thank you.

You also mentioned the expansion of grid——

Ms. CASTOR. I am sorry—I am sorry, Mrs. Miller. Your time has expired.

Mrs. MILLER. Thank you.

Ms. CASTOR. And I would also like to ask members to please refrain—I know we don't share all of the same views, but I would ask that we not make any personal attacks on any individual, especially if they are not a party to our hearing today.

And, next, we will go to Rep. Bonamici.

You are recognized for 5 minutes.

Ms. BONAMICI. Thank you, Madam Chair and Ranking Member Graves and our witnesses.

And thank you, Madam Chair, for noting that. I thought the comment was unnecessarily confrontational. We are here to have a debate about policy, not personal attacks.

So I am here in the Pacific Northwest, and we are no stranger to extreme weather and natural disasters that stress our energy grid. And, last summer, we had unprecedented heat waves sweep across Oregon, causing extreme precautions, including shutting down Portland's streetcars and light rail system to prevent equipment from melting.

Portland General Electric—and thank you for the shout out, Dr. Wayland—PGE relied on a demand response program that helped prevent a worst-case scenario. It is a program that compensates consumers and businesses for shifting energy used during peak demand. PGE estimates that this program saved about 62 megawatts of power during the June 2021 heat wave, and that was enough to power 25,000 homes.

So, Dr. Wayland, what are some of the policy changes inhibiting utilities around the country from implementing their demand response programs or increasing consumer participation?

Dr. WAYLAND. That is a great question. When I was at the Department of Energy, I looked at the demand response capacity around the country, and it is quite significant, the amount of energy—even if you just look at large customers, not at ways that we can encourage smaller residential customers to be involved in demand response programs. And the delta between the demand response capacity and the actual contracts that we had was pretty large. And then the delta between the contracts that we had and what was actually delivered when called upon was also pretty large.

So I think that there are a number of both regulatory pricing structures that—signals that can be sent, but also encouraging customers to join these programs and also encouraging third-party aggregators to go out looking for those customers.

And I think what you will see with FERC Order 2222 is a growth in the aggregators who are going out and looking for those distributed energy resources, whether they are going to bundle them into the wholesale market for power or for demand response programs.

So there is a number of things that can be done there with demand response.

And I do think that what we will see increasingly is the smaller customers becoming part of demand response programs as a result of—and these would be active load management programs—but as a result of smart appliances and smart thermostats and ways that residential customers can participate and benefit and earn money from participating in these programs, but do it in a way that they don't have to think about it, where it is really automated.

And, again, that only happens if we have a very smart grid that allows communication with these customers.

Ms. BONAMICI. Exactly.

Dr. WAYLAND. So the flexibility funding, the Smart Grid Investment Grant flexibility funding, and the broadband funding—and, of course, broadband is going to be the backbone of a smart grid in

the future, whether it is wireless or fiber—and the funding in the bipartisan infrastructure law will actually help support demand response programs.

Ms. BONAMICI. Terrific. Thank you so much.

So, this year, coal will account for about 85 percent of electric generation capacity retirements, while solar and wind are projected to account for about 63 percent of new capacity. Investing in the bulk power system has been and will continue to be critical to a resilient grid, especially as polluting baseload generation is taken off line and replaced by renewable resources.

So I wanted to ask you, Ms. Hamilton: In your testimony, you mentioned the importance of building inter-regional transmission lines. How would ratepayers benefit from transmission build out? And how does the Build Back Better Act help us with this goal?

And thank you for pointing out in your written testimony and your oral testimony the Boston Globe article that said, compared with climate inaction, Build Back Better is downright cheap.

So will you please talk about how ratepayers would benefit from that transmission build out and how Build Back Better would help?

Ms. HAMILTON. Yeah, absolutely. Thank you so much for that question.

So there was a recently released Grid Strategies report that says, for every $1 invested in transmission, customers see $3 in benefits. And that is because it keeps the prices down for customers. You are able to move electricity from places that have a lot of resource to places that have a lot of load. And you can do that in real time with a lot of different technologies that are available today.

So, for example, you look at what we have in our nation today, and a lot of our systems are very isolated from other systems. Right now, there is no connection, a seam, between MISO in the Midwest and PJM, which has an enormous amount of load. So, like, let's build a transmission tie there to move all of that great wind out of Iowa into Chicago that is going to need it, especially with their new goals.

And so what we need to do—and when you look at Texas and the lack of ties that they had during the polar vortex, how difficult that was for them to manage the system. Whereas in MISO, across Louisiana, Mississippi, Alabama, Indiana, there were more transmission ties. They were able to import 15 times more power than Texas was, simply because they had transmission ties.

So transmission is incredibly important. And I think if we look at transmission overlaid with our rail, with our highway rights of way, there are plenty of ways to get transmission built.

And if you look at what right now is in the infrastructure bill, there are certainly programs that are going to be able to incentivize that and allow us to be catalytic. So perhaps funding one project will lead to not just that project being built but really catalyze multiple projects after that by sending the signal to the private sector that you can build transmission now.

Ms. BONAMICI. That is great. Thank you.

And my time has expired. I yield back. Thank you, Madam Chair.

Ms. CASTOR. Thank you.

Next up, Rep. Gonzalez, you are recognized for 5 minutes.

Mr. GONZALEZ. Thank you, Madam Chair.

And thank you to our witnesses.

I want to start by submitting for the record from Stanford University, "An Assessment of the Diablo Canyon Nuclear Plant for Zero-Carbon Electricity, Desalination, and Hydrogen Production," for the record.

Ms. CASTOR. Okay. Without objection, so ordered.

[The information follows:]

Submission for the Record
Representative Anthony Gonzalez
Select Committee on the Climate Crisis
February 15, 2022

ATTACHMENT: Aborn, J., Baik, E., Benson, S, et al. (2021 November). *Assessment of the Diablo Canyon Nuclear Plant for Zero-Carbon Electricity, Desalination, and Hydrogen Production.* Stanford University.
This report is retained in the committee files and available at:
https://energy.stanford.edu/sites/g/files/sbiybj9971/f/diablocanyonnuclearplant_report_11.02.21.pdf

Mr. GONZALEZ. Thank you.

I want to first just cite something from there. We have talked about the impact that Diablo Canyon could have on California's energy. This report analyzed various scenarios and concluded that keeping Diablo Canyon running would, quote, "significantly reduce California's use of natural gas for electricity" and "save $2.6 billion in costs to the state's power system from 2025 to 2035."

Additionally, if closed, a carbon-free electrical system in California in 2045 would need 18 gigawatts of PV solar and 11 gigawatts of energy storage, and the additional capacity of solar to replace Diablo Canyon would take up 90,000 acres of land. By comparison, the footprint at Diablo Canyon is just 900 acres and only 140 acres for the plant itself.

So hopefully that provides some context for folks. I think shutting down any nuclear plant in this country is insane, yet it is something that people continue to do for some reason.

So, that being the case, we obviously disagree on policy, but I do believe all of us here believe American families and businesses deserve access to affordable, reliable, and resilient energy. That is why I have been an advocate for generating electricity from a diverse set of energy sources, including nuclear. You all are probably sick of me saying that at this point, but I just think it is a no-brainer.

Mr. Mills, in your testimony, you highlighted a case study that I bring up quite frequently at this committee, and that is Germany's high-priced transition to renewables.

In Germany, wind and solar make up roughly 20 percent of the energy mix, and supply anywhere from a negligible amount to roughly half of all demand during certain sunny and windy hours. These large fluctuations require backup from other power plants, typically coal- or gas-fired, or increased electricity imports. And, as you noted in your testimony, all this variability can cause serious disruptions in electricity flow and, thus, dramatically raise consumers' prices without a significant reduction in emissions.

Now, when I raise these concerns and specifically cite the emissions and costs from Germany, one response I often hear is that,

because the U.S.'s geography and resources is dramatically different than Germany's, there is no reason for us to be concerned with the consequences of pursuing the exact same policies. Some would suggest, hey, it is sunny in Arizona, so that should work fine in northeast Ohio. I would argue that is also kind of crazy.

Can you help us understand why it would be a mistake for the U.S. to support and implement the same renewable energy strategy as Germany?

Mr. MILLS. Well, I encounter the same comments, Congressman Gonzalez.

I think the answer, first of all, is that the European grid does have a lot of interties there. It is a fairly integrated set of grids among many countries. The geography of continental Europe from its south to its north is very similar in terms of the latitude and, therefore, solar insolance, very similar in terms of wind. Some of the challenges there intercountry are moderated much like we have here with our FERC.

So the reality is, in terms of the primary resources, wind and sun, if that is where most of the expanded capacity is focused, it is not very different, continental United States and continental Europe.

And the other reality is, of course, that Germany has done the experiment for us, as has England, where you provide reliability by essentially building two grids. And even if the two sources of electricity—broadly speaking, the hydrocarbon traditional sources and the newer sources, wind and solar—were the same price, you have, by definition, roughly doubled the cost of the supply system.

And you increase costs because you need more interties. I think we do and should have more interties, but you need more of them. And then you have to underutilize the—we will call it the old grid. Underutilized assets cost more per unit of energy delivered and actually have operational structural cost increases on grids when you start doing cycling of these assets.

So they have done the experiment, and it does cost more. I think people need to be honest about the fact it just costs more, not less.

Mr. GONZALEZ. Thank you.

And with my final 30 seconds, the suggestion that we can just send solar power from places like Arizona all over the country and that is somehow a solution to our grid challenges, that is sort of silly, right?

Mr. MILLS. Well, you can do it, but it costs a lot of money and exposes the long transmission lines to precisely the extreme weather events people are worried about. It is expensive, and it doesn't guarantee it will have enough of the physical resource available when required, for the exact meteorological reasons I point out in my testimony.

Mr. GONZALEZ. Thank you for your responses.

And I yield back.

Ms. CASTOR. And, next, we will go to Rep. Brownley.

You are recognized for 5 minutes.

Ms. BROWNLEY. Thank you, Madam Chair. And thank you for pulling us together for this important hearing. I appreciate it very, very much.

Ms. Sutley, I was particularly interested in your—particularly your written testimony, and in talking about green hydrogen, and not only in terms of getting to your 2035 goal but also in terms of, you know, reliability in and of itself.

So I am sort of curious, is the use of green hydrogen, is there—obviously, to expand your renewable energy options in your portfolio has got to be one reason, certainly. But I was curious to know, is there something special around green hydrogen when you were talking about reliability, other than just its availability?

Ms. SUTLEY. Thank you.

When we looked at the—well, the "LA100" study looked at what was necessary to get us to 100 percent renewable energy, the National Renewable Energy Laboratory pointed out that we do need dispatchable capacities, as Mr. Mills was mentioning. We agree with that. But one way to provide that is with green hydrogen.

We understand from the people involved in the technology that, you know, a certain amount can be blended into a power plant today and that, you know, the technology is evolving to ensure that we can use 100 percent green hydrogen in a combustion turbine in the future. And so that would provide that dispatchable capacity.

The "LA100" study also pointed out that it would be different than we use our natural gas power plants today in the L.A. Basin, where they run much of the time, probably 30 percent of the time, to where we would be using that dispatchable capacity infrequently, in times of very high demand or where there was an interruption for some reason in the grid where we couldn't import some of the renewable energy that comes from outside of the Los Angeles Basin.

The other thing is, we were part of a consortium that is retiring a coal plant in Utah and are looking at green hydrogen and the ability to actually make it on site through electrolysis and store it on site and potentially provide seasonal storage of excess renewable so that that renewable energy when it is available can be used to make the green hydrogen, and then at that particular site we can store the green hydrogen on site and use it when it is needed for the grid.

Ms. BROWNLEY. And I notice in your testimony, too, in terms of storage of that, it is in salt caverns that Utah has, but that has to be a cheap way, I would imagine, in terms of storing energy?

Ms. SUTLEY. Well, it's—yeah, that may be some—there may be some particular things about that site that are particularly attractive but we also think a good opportunity to show how this technology could work.

There are extensive salt caverns underneath this power plant. There is water, there is gas lines, there is power lines that bring renewable energy both into that area and then energy from the plant into southern California. So it is sort of an ideal place to do this kind of project.

Ms. BROWNLEY. And when do you think you will get to 100 percent green hydrogen?

Ms. SUTLEY. Well, at that plant, the new turbines are coming in in 2025, and they will be capable of burning about 30 percent hydrogen the day they are turned on. And over the next decade or so, as it goes through its maintenance cycles, the plan is to convert

it probably in the mid-2030s to something that can run on 100 percent green hydrogen.

Ms. BROWNLEY. Great. Thank you so much.

And, Ms. Hamilton, I have about 30 seconds left, but, you know, in your testimony, you really talked about microgrids, and certainly they are very important when we are talking about resiliency and reliability.

And I was particularly interested in—you gave a couple of different examples, and one of those examples was the Sonoma Valley Unified School District, in terms of what they are doing. And I am a former school board member, and so I can't get away from it too far.

But, you know, just in thinking about that and the possibilities of microgrids being, you know, judiciously spread across particularly the State of California, when we are thinking about that, seems to be a great win-win opportunity. And, actually, school districts could actually perhaps earn some revenue in terms of education for their kids.

So do you agree with all of that and that assessment?

Ms. HAMILTON. I do. Not only can they bring solar on line, they can earn more money by participating in the wholesale market, and they can charge electric school buses. And if you have ever sat in the back of a school bus, you know it is stinky, and electric school buses are really the way to go for these school districts. And the microgrid supports all of those.

Ms. BROWNLEY. Thank you so much.

And, Madam Chair, I yield back.

Ms. CASTOR. Thank you.

Next up, Rep. Carter, you are recognized for 5 minutes.

Mr. CARTER. Thank you, Madam Chair.

And thank all the witnesses for being here.

I will go ahead and get this out of the way. Georgia is the number one forestry State in the nation, and I am very proud of that.

Thank you, Ranking Member Graves, for bringing that to my attention before I get started.

Mr. Mills, I wanted to direct some questions to you.

Look, we all agree—we all agree that we need to modernize our grid. Everybody here; we disagree on how we do it, but we all agree we need to modernize it. I don't think there is any question about that.

We know that our economy is electrifying more and more, and, as a result of that, we have to have both generating capacity and grid capacity, and we have to increase that significantly. And, again, I think everybody agrees with that.

You make that point, Mr. Mills, in your testimony, and I appreciate that very much.

And I am not against using any particular or any specific type of form of generation, whether it be wind, solar, or whatever. I am an all-of-the-above type guy as far as the energy goes. But the reliability and the resiliency are extremely important to me, and also the affordability. You just mentioned when we were talking about getting solar power from Arizona, you know, the cost of the transmission lines. Obviously, that is something that would deter us. I

mean, that makes sense to anybody. I think a third-grader could understand that.

But you also mentioned in your testimony that, if we were to primarily switch to solar and wind, that the battery storage would—that is necessary for 12 hours, we would need to spend almost a trillion dollars on batteries alone. Not to mention how we make those batteries, the energy that it takes to make those batteries, and what we do after they are no longer being used. Those are things we should consider as well.

But the one thing that I am really concerned about, again, is the reliability and the resiliency. And I wanted to ask you: You understand just like all of us do what is going on right now with rising energy costs. You have seen it; we have all seen it. In light of that, what can we expect to happen to electricity rates if we were to make such a transition as some have described here—that is, to try to go totally to wind and solar and do away with all the other sources?

Mr. MILLS. Well, thank you, Congressman. I think we know the answer because it is already happening in the United States and around the world: electric rates are going up, not down.

And there is a one-to-one correlation in European nations and in the United States, in U.S. regions. As more wind and solar capacity is added per capita, electric rates are going up.

And that is not a subsidy effect, in the sense the subsidies should keep the rates down because the capital costs are shifted from the ratepayers to taxpayers broadly. That is where the subsidies come from.

So the fact electric rates are rising—in fact, in Xcel service territory, they have gone from a few percent wind plus solar to about, I think they are at 10 or 12 percent now, maybe 15, and the average costs of electricity for the average homeowner has gone from $800 a year to $1,600 a year.

So, you know, they are following the path the commission wants and that we all would like to have, more wind and solar, but it costs more money—it has been costing more money. The idea that it will get cheaper in the future is entirely anchored on forecasts, not on experience.

What is actually happening is solar module prices have gone up 50 percent in the last 2 years. Battery costs are forecast to rise this year. Wind turbine costs have stopped—prices have stopped going down, are going to rise slightly this year, all because of the commodity inputs for them. Commodities account for 60 to 70 percent of the cost of making solar panels, about 30 percent of the cost of making wind turbines. When commodity prices escalate, it ripples through. It ripples through other things too, for fertilizer, food——

Mr. CARTER. Right. Right. And——

Mr. MILLS. But that is the path that we are on.

Mr. CARTER [continuing]. I have just got a minute left. And you just answered my second question, and I appreciate that, about the increasing cost. And, obviously, we all understand that.

But how can we ensure that our transition—if we were to transition too quickly, obviously we are going to bring into light the reliability and the affordability. But how can we transition significantly investing in the grid in a way that doesn't necessarily put

this undue pressure on electricity rates and how we could reduce affordability?

Mr. MILLS. Well, so I am sorry the answer is to go slower. And no one likes that answer, because to get the cost down of the technologies we would like, they are going to take a lot longer to get cheap.

I would just mention quickly, hydrogen on a unit of energy delivered basis is about 300 percent more expensive than natural gas. There is no path to making hydrogen as cheap as natural gas anywhere visible in any of the physics or physical chemistry.

So it works; you can electrolyze water and make hydrogen. It doesn't matter that you use solar panels to do that. It produces very expensive energy. It is a solution. I like hydrogen fuel cells personally. We can burn it in engines. It——

Mr. CARTER. As do I.

Mr. MILLS [continuing]. Is just very expensive.

Mr. CARTER. Good.

I know I am out of time, and I will yield back, but thank you, Mr. Mills, for making what I consider to be very important points.

Look, we all want the same thing, but how we get there is I think where we differ.

Ms. CASTOR. All right.

Next up is Rep. Huffman from the Redwood forests.

Mr. HUFFMAN. Thank you, Madam Chair.

I wanted to show you a little bit about what California really looks like. It is not this, you know, doom and gloom place that some of my colleagues have been describing. In fact, I am sitting here in my home powered 100 percent by renewable energy right now, and the lights are still on and I think my connection is still working.

It is amazing, this alchemy, this magic, we have been able to achieve in California, contrary to all of the anti-renewable doom and gloom we continue to hear from the other side, who for some reason thinks that we have to go slow and we should not go too fast in this transition to clean energy. Let's keep in mind, we have a climate crisis out there, and there is an enormous cost of making this transition too slowly. We should talk about that cost as well.

But, look, I don't want Mr. Carter to be the only one to brag about his state. We hear a lot about the beautiful State of Georgia, Mr. Carter, but let me tell you a little about California.

Right now, in real time, we have this wonderful website that our grid operator, the California ISO, puts out there. You can go to CAISO.com, and you can see that, right now, as I am talking to you, we have a current demand of a little over 22,000 megawatts. Over 70 percent of that demand right now in real time is being met by renewable energy. And somehow the California economy, fifth-largest economy in the world, is plugging right along.

Only about 9 percent of our energy in this moment is imported, contrary to some of these claims about our extreme dependence on imported energy. We have an increasing amount of battery storage that is helping keep our grid working. None of it is contributing to our load right now because the sun is shining and the wind is blowing, and so we are charging those batteries.

And, as we go forward, those batteries as well as our hydro and our other assets, including geothermal, which is about 5.5 percent of our load right now as we speak, are going to keep our grid balanced. And, in fact, the grid has never failed here because we had too much renewables. This is a canard, this is a myth that we continue to hear. In fact, I am not aware of any grids failing anywhere because there were too much renewables.

I am aware of Tucker Carlson and Ted Cruz and Republicans claiming that the Texas failure last year was because of too much wind, but that just forced the fact checkers to totally debunk that. The turbines kept working; the wind worked just fine. It was, in fact, a deregulated grid that depended on some really neglected fossil fuel infrastructure that brought all of the reliability problems in Texas.

So we do a lot of debunking and fact checking when we try to have a forward looking conversation in this committee, and I needed to cover some of those bases, but I want to bring this back to Nancy Sutley.

We are proud of the fact that LADWP is one of the nation's largest utilities and you have set these great goals for 100 percent clean energy. How are you going to make this magic alchemy happen without crashing your grid, as we have, you know, heard all these warnings about too much renewables?

Ms. SUTLEY. Well, thank you, Mr. Huffman, for the question. Well, I would say a couple of things.

First of all, we have this "LA100" study done for us by the National Renewable Energy Laboratory that literally looked at thousands of scenarios and modeled L.A.'s grid literally down to the building level and came up with a number of scenarios that would get us to 100 percent clean energy reliably, affordably, and equitably, including by 2035. The state's current goal is 2045 for a 100 percent clean energy grid.

And then the second thing is that, you know, we have been making these investments in renewable energy. We have brought on line a number of new projects, including some of the cheapest solar to date and cheapest wind to date. We have invested in storage. We have sort of repurposed a hydro pump storage project that was built in the 1980s to work alongside the renewable energy to provide that, sort of, longer duration storage. And we are investing in, sort of, management of the grid. And we believe that even on, kind of, our current investment path that we can get to about 80 percent renewables by 2030 and 97-percent greenhouse gas free.

So looking at a diverse energy source—diverse clean energy sources and continuing to invest in our grid to protect reliability and to invest in electrification and energy efficiency and demand management that help our customers help us manage the grid. So——

Mr. HUFFMAN. Thank you.

Ms. SUTLEY [continuing]. We believe this is all possible.

Thank you.

Mr. HUFFMAN. I realize, Madam Chair, I am out of time. I had another question I wanted to ask other witnesses about some of the microgrids we have begun to deploy and the big grid/little grid

issue. If there is a second round, I will hang around for that. But I am out of time, and I will yield back.

Ms. CASTOR. Thank you, Rep. Huffman.

Next, Rep. Palmer, you are recognized for 5 minutes.

Mr. PALMER. Thank you, Madam Chairman. And thank the witnesses and Ranking Member Graves.

Mr. Mills, The New York Times put out an article last week, couple weeks ago maybe, that showed where we would have to locate solar farms and wind farms for generating the power that the nation would need to run on, and a lot of that was in the Midwest. Would that not create some major eminent domain issues?

Mr. MILLS. I am sorry, what kind of issues, Congressman? I apologize.

Mr. PALMER. Eminent domain.

Mr. MILLS. Oh. Yeah, I think—well, certainly, this administration and previous ones have struggled with the eminent domain challenges with building any large scale facilities that take acres and acres or millions of acres. Transmission line has failed serially to get clean hydro from Canada down into New York City.

So the opposition to using large areas of land for wind and solar is rising, but that is—you know, everyone is familiar with the NIMBY challenge. It is not new. Yeah, I think it will become more severe as we expand the use of wind and solar, sure.

Mr. PALMER. Well, it already has with transmission lines, and——

Mr. MILLS. Certainly.

Mr. PALMER [continuing]. We are taking an enormous amount of land to site these solar farms and these wind farms.

The other thing is—you are involved in engineering. I worked for two international engineering companies. Just from an engineering feasibility perspective, from my understanding of engineering, it is not feasible to build this out in 13 years, by 2035.

Mr. MILLS. Well, not at the national level it is not. There is not enough construction capacity to do it. And as we push the construction capacity hard, you get price escalation, you get labor cost escalation, and materials escalation. And if I——

Mr. PALMER. There are shortages, as you have already pointed out, particularly in rare earth elements. As you pointed out, half of that is controlled by China. And I think we get 80 percent of our rare earth element material from China.

Mr. MILLS. Right.

Mr. PALMER. But Finland—in one of the articles that you wrote, you quoted the geological survey by the Finnish Government about the capacity for providing the other materials, I mean just basic materials. Could you comment on that?

Mr. MILLS. Certainly.

And just for the record, you know, I have worked for dozens of utilities over the years. I have to—some of the most impressive engineering anywhere on the planet is in American utilities. They have kept the lights on, as the Congressman has observed, and done so under duress many times, both from nature and from human nature.

What the Finnish Geological Survey did was look at the global plans—many countries are emulating what the United States is

talking about—to do a transition to using lots more wind, solar, and batteries, and water electrolysis. We can throw that in as well. And they calculated the existing availability of known reserves of minerals—copper, nickel, lithium, cobalt—not just the rare earths.

And their conclusion—and this is not an anti-renewable energy conclusion. It is simply an analysis, the same that was done by the Dutch Government at the Delft University. The world doesn't have enough proved reserves, not just mines——

Mr. PALMER. Thank you.

Mr. MILLS [continuing]. Of the minerals that are needed to fabricate all the machines that are being contemplated right now.

Mr. PALMER. And wouldn't it make more sense to utilize next generation nuclear, which can utilize and recycle spent fuel rods, instead of putting all of our eggs in this renewable basket?

And it seems even dumber to me that the Biden administration is rejecting or rescinding permitting for a nickel and cobalt mine in Minnesota when we know you have to have that to build these facilities.

Mr. MILLS. Well——

Mr. PALMER. Does that make sense?

Mr. MILLS [continuing]. Yeah, we need a lot more—I am a nuclear bull. I think there is a tremendous opportunity for more both small and large nuclear plants. I am also very bullish on literally doubling the amount of solar/wind capacity in America, more than tripling the battery capacities on grids. This is going to happen. It is useful.

What I challenge is a future that is fully dependent on that, because the data don't show that is possible. Nuclear has a very important role in all this.

Mr. PALMER. Well, that is the point that I wanted to make. And you look at what has happened in the U.K. and in Germany and how much household utility costs have gone up, how it has impacted the lives of particularly lower income people. It has literally created energy poverty——

Mr. MILLS. Right.

Mr. PALMER [continuing]. In Europe and the U.K., and it has here to a certain extent as well.

With that, Madam Chairman, I yield back.

Ms. CASTOR. Great. Thanks, Rep. Palmer.

And, fortunately, in the bipartisan infrastructure law, we were thinking ahead, and it includes some new policy direction on presiting consultation to try to avoid any problems with—and that includes siting backstop authority for DOE, because there are issues when you are trying to plan interstate power lines and transmission lines. And I hope somebody will ask our experts to expand on that as well.

Next, we will go to Rep. McEachin.

You are recognized for 5 minutes.

Mr. MCEACHIN. Thank you, Madam Chair. And, again, I want to thank you for your marvelous leadership of this committee and for having this hearing today.

The Congress—this Congress, at least—and the Biden administration have taken steps through the bipartisan infrastructure law to increase the reliability and resilience of our grid in the face of

extreme weather events and significant risks that are posed to our nation's electric grid. These investments are critical, and I look forward to the continued work with my colleagues to implement these investments and ensure continued efforts to make our grid more resilient and reliable, including those included in the Select Committee's Majority Staff Report.

Ms. Sutley, environmental justice communities are on the front lines of the climate crisis. In your testimony, you explained that moving to a zero carbon grid will help reduce air pollution, including nitrogen oxides and fine particulate matter. Can you explain how this process might play out?

Ms. SUTLEY. Thank you, Representative, for the question.

Yes, we have seen here in Los Angeles—we still have the worst air quality in the nation. Smog and particulate matter pollution affects many of our communities, particularly low-income and disadvantaged communities. But most of it right now is coming from the transportation sector. It is coming from the cars on the road, the trucks and buses and the goods movement coming out of the Ports of Los Angeles and Long Beach.

And so, as the grid gets cleaner and cleaner, electrification of those transportation sources will help to get rid of the largest sources of smog pollution and other toxic air pollution that is affecting our communities.

So we believe that, even today, electric vehicles or other electric equipment, today, even with the power mix on our grid, is up to four times cleaner than the diesel or gasoline powered vehicles that are on the road today. So we are able, as we electrify, to address the major sources of air pollution that are harming our communities.

Mr. MCEACHIN. And let me ask you this question, ma'am, if I can. You know, we are trying to invest to do the very important work of grid resilience and grid reliability. As we do that, how do we also advance the cause of environmental justice?

Ms. SUTLEY. Well, we are right now engaged in a community-based and community-led effort around equity strategies as we implement these policies and these programs to get us to 100 percent clean energy. We have really tried to make sure that all of our communities are benefiting from these investments.

So, for example, you know, many residents in Los Angeles are renters. They live in apartments and can't necessarily put a solar panel on their roof. So we have created a shared solar program where apartment dwellers can take advantage of solar energy.

We are also investing in electric vehicle charging infrastructure in disadvantaged communities. So, for example, we have a customer service center in the Crenshaw neighborhood of south Los Angeles where we have installed a number of electric vehicle chargers that are available to the community. And they are very popular and they are used all the time.

So I think what we are trying to do is really be deliberate about addressing the needs of the community and taking the input of the community to do that.

Mr. MCEACHIN. Okay.

With an organization like yours, how can this Congress or any Congress be a strong partner to help you in your efforts to advance

environmental justice? In other words, what else can we do or what else should we be thinking about?

Ms. SUTLEY. Well, as I said, the biggest, sort of, bang for the buck on that right now is to reduce the pollution coming out of our transportation sector, and electrification really offers a pathway to do that in a cost effective way.

And so the investments that the Congress made in the bipartisan infrastructure law and contemplated in Build Back Better, as well, will go a long way to building both the charging network that will allow that large scale electrification of transportation and also support the vehicles being on the road today.

Mr. MCEACHIN. Thank you. I think Los Angeles is lucky to have you. Thank you for all your hard work.

And, Madam Chair, I yield back.

Ms. SUTLEY. Thank you.

Ms. CASTOR. Thank you, Rep. McEachin.

Next up, Rep. Armstrong, you are recognized for 5 minutes.

Mr. ARMSTRONG. Thank you, Madam Chair.

And thank you, Mr. Mills, for talking a little bit about the economics of hydrogen. Hydrogen is a great fuel source. The problem is, you can't economically scale up the electrolysis for green hydrogen without it being unbelievably expensive to consumers under current technology.

And if you use gray hydrogen, you need to have natural gas as a feedstock, which, while very effective, one, doesn't help the carbon emissions as much and, two, it is pretty hard to compete with natural gas when you are using natural gas as a feedstock, regardless of the price of natural gas.

But the Majority's memo for this hearing highlights a previous staff report that recommends backup storage as a means to address instances when intermittent generation sources are unavailable to provide electricity—essentially when the wind doesn't blow and the sun doesn't shine. And we have seen this argument before. Proponents of widespread renewable deployment advocate that batteries are the answer when those sources are completely offline. But this argument ignores the reality of our technological, material, and production limitations.

And, Mr. Mills, when you have written on this topic, you have often framed the scale of this problem using the world's largest battery manufacturing facility, the Tesla Gigafactory in Nevada. Using current levels of production, approximately how long would it take to produce the number of batteries to store 2 days' worth of U.S. electricity demand?

Mr. MILLS. Well, the short answer is: centuries. Or, put differently, you have to increase by a hundredfold the global manufacturing capacity, which is not happening because it can't happen.

Mr. ARMSTRONG. Well, and your critics argue that, right, with additional battery facilities——

Mr. MILLS. Right.

Mr. ARMSTRONG [continuing]. Will be built over the next decade to add to this production. But it completely ignores the reality of global supply chains and the availability of essential materials like, I mean, lithium, cobalt, just to name a few.

Mr. MILLS. Well, that is correct. And I want to again go on the record of pointing out that I am reflecting observations about mineral supplies made by the U.N., by Geological Surveys in European nations, by the EU itself, by the way, and by the IEA's magnificently long and detailed report on the minerals required they published last year to very little fanfare.

Mr. ARMSTRONG. Well, and I say that a lot in this hearing and others. And I think one of the fundamental things that I get so frustrated with is, a lot of our policy seems to be outsourcing our guilt. I mean, by your admissions, right, we are going to have to increase lithium mining by at least 500 percent worldwide.

Mr. MILLS. Right.

Mr. ARMSTRONG. And, I mean, given the regulatory hostility in the United States, do you think it is realistic that we can onshore that production?

Mr. MILLS. No. If the average time to open a new mine anywhere in the world is 16 years, average, the United States is far longer. Mines have been canceled recently. This administration canceled the Minnesota copper/nickel mine just a week and a half ago.

So, just as a practical matter, even if we were all enthusiastic, as I am—I worked for a mining company in Canada years ago. I am bullish on mining. I think we should open more mines here. I think we should require more mining here as a condition of more green energy machines being built here. I think we should link them, personally. But it will take decades, not a few years, to expand mining capacity, not only here but globally.

Mr. ARMSTRONG. Well, and I think we are seeing that in real time right now, the impacts of global supply chain, with the United States almost entirely dependent on what I would call our strategic global adversaries for critical minerals.

I mean, palladium is an essential material used for catalytic converters to clean auto emissions——

Mr. MILLS. Correct.

Mr. ARMSTRONG [continuing]. And Russia is currently the largest producer of palladium. In fact, they produce more than the next four countries combined.

And just in the real world, how this is working today, as tensions on the Ukrainian border have increased over the last 2 months, so have palladium prices, simply due to the market making assumptions about future access. With news this morning that the Russian troops near Ukraine might be returning to their bases, palladium slid 5 percent.

What happens when something beyond market forces limits the availability or alters the price of these materials, particularly when they are produced by our strategic adversaries and we have no realistic way to onshore them?

Mr. MILLS. Well, we have a realistic way to onshore a lot more of it; it just takes time. That is why—I wasn't being facetious about going slower. We can't build these things faster. We have to recognize, not as a policy matter, that we should slow down; I think we have to recognize the velocity with which global-scale mining and manufacturing can expand to our aspirations. We should expand them. I think we should try to accelerate them. But I don't think they can go at the pace people imagine.

America has plenty of minerals. The United States just hasn't had the appetite to provide the right incentives to expand mineral processing and mining. And both are required, not just the mining, but the very difficult chemical processing that happens after you dig up the rocks is something else that we are not a very friendly nation to the expansion of those kinds of industries.

Mr. ARMSTRONG. And I agree with that. I mean, we have a lot of lignite coal in North Dakota. We have a lot of people who would do a really good job of getting that out of the ground. It also happens to be pretty high in rare earth metals. But I—and my dad used to tell me this when we were hunting when I was a kid. He said, "Slow is steady, and steady is fast."

And, with that, I will yield back.

Ms. CASTOR. Okay. Thank you.

Next up, Rep. Levin, you are recognized for 5 minutes.

Mr. LEVIN. Well, thank you very much, Chair Castor.

I wanted to start off with what I believe has been a great California success story, and that is the expansion of rooftop solar in the State of California.

And, Ms. Sutley, it is good to see you. I will start with you.

I think as you know, across California we now have 1.3 million Californians who have installed a total of about 10 gigawatts of rooftop and home-based solar.

And, in your testimony, you referenced how NREL recently completed its "LA100" study, which examines various scenarios for how Los Angeles can reach 100 percent carbon free energy by 2035. The study covers how L.A. alone has over 13 gigawatts of solar rooftop potential, over half of which is the residential sector.

Can you discuss the role that rooftop solar, coupled with energy storage, needs to play for L.A. to meet its clean energy and grid resilience goals?

Ms. SUTLEY. Thank you, Representative Levin. Nice to see you. I appreciate the question.

Yeah, there is no question that rooftop solar will play an important role in us meeting our clean energy goals. Los Angeles is proud to be the number one solar city in the country, and we have long supported our customers in embracing rooftop solar through the California Solar Initiative and solar incentive programs.

We have a feed in tariff program that really looks at, sort of, a power purchase agreement with us, you know, to incentivize solar on, for example, warehouse roofs—we have a lot of those in Los Angeles—as well as recognizing, as I mentioned, that 60 percent of our residents live in multifamily dwellings, and so we have to design other kinds of solar programs to ensure that folks can access the benefits of solar energy through our shared solar program as well as the solar rooftop leasing program to basically lease people's roofs for solar that they might otherwise not be able to afford to put on their own roof.

So it has been a very successful program, but I think it recognizes, and the NREL study recognizes, that we need that local generating capacity here in the Los Angeles Basin. We do get a lot of our power imported. That has been going on now for many decades. It used to be coal plants in Arizona and Nevada and Utah, and now, increasingly, solar and wind coming from other parts of Cali-

fornia as well as from other Western states. And we do have the transmission to support that.

But, really, for that, to maintain resilience and reliability, we need local sources of generation, including rooftop solar. And we are fortunate in Los Angeles we have, you know, 350-plus days of sunshine a year, and it makes it an ideal place to really make rooftop solar a critical part of our energy future.

Mr. LEVIN. Fantastic. Thank you for that.

And I am glad that the California PUC has indefinitely postponed its changes to net metering. Because I want to make sure that, as we look at the Federal level to make investments in clean energy, California continues to adopt policies that really keep rooftop solar deployment growing rather than undermining that growth.

Ms. Hamilton, I will turn to you. It is nice to see you. As my colleagues have discussed, the bipartisan infrastructure law included a lot of funding to modernize our grid and to advance energy storage. In your testimony, you discussed how the Investment Tax Credit included in the House Build Back Better Act would help drive down the cost of energy storage and solar and transmission.

I would also like to note the inclusion of direct pay provisions. I have been advocating for that, really building on something that Earl Blumenauer and I introduced, the Renewable Energy Investment Act. Direct pay, I think, is particularly important as we continue our economic recovery, since the volatility driven by the pandemic has made it more challenging to finance clean energy projects.

With the time I have left, could you elaborate on why this is all critical, these tax policies are critical, in building grid resilience?

Ms. HAMILTON. Yeah, absolutely. Thank you so much for the question, Mr. Levin.

The tax credits will send a signal to the private market. And direct pay is incredibly important for those people who do not have a tax burden. And so, as you are talking about rooftop solar, there is a 10 percent bonus credit for rooftop solar for people in low-income communities, and there is a 20 percent for community solar for low income communities. That is incredibly important. And direct pay will help those people who don't have tax burdens to be able to take advantage of those kinds of systems.

The other thing is, for energy storage, you know, there are a lot of technologies other than batteries. There are long-duration storage projects, including in Mr. Carter's State of Georgia. Georgia Power is proposing in their Integrated Resource Plan to install a long-duration storage battery that will accommodate seasonal storage. That is the kind of project that will also benefit from a tax credit.

And there are investors—and I have worked for a private equity company before—who will say, this means we are ready to invest and we are ready to move forward on these technologies. So having the Tax Code signal that to the private sector is really crucial.

Mr. LEVIN. Thank you.

I am out of time, but I thank you both for your leadership.

And I will yield back, Chair.

Ms. CASTOR. Thank you, Rep. Levin.

Next, Rep. Crenshaw, you are recognized for 5 minutes. Welcome.

Mr. CRENSHAW. Thank you, Madam Chair.

And thank you to the witnesses.

You know, I just want to address this notion that we should sprint to what are inherently unreliable forms of weather energy. And the narrative goes something like this: we have to sprint there because there is a crisis and it is an emergency.

And I would challenge my colleagues to point out where in the U.N. IPCC report it says there is a climate crisis. It does say, there are costs. The costs are about 4 percent of global GDP, and by the year 2100 that is 4 percent less than it otherwise would be. That is not nothing, but it is pretty close to nothing.

The recent statement by the New York Federal Reserve stated very clearly, after researching this topic extensively, that the costs of the proposed climate policies are far greater than the costs of climate change itself.

So we don't want to debate climate change here, but we do have to get at the actual facts and what the consensus, the scientific consensus, dictated by the United Nations, actually says. Because that informs our thinking moving forward. It informs our solutions. And it actually tells us it is pretty good news. You don't have to sprint to unreliable energy.

Let's take a look at Texas. Texas has 30 gigawatts of wind capacity. That is enough to power the whole state. Now, the thing is, when the weather gets really bad and it freezes—and, by the way, it didn't just freeze in Texas; in surrounding states, too, they also couldn't get power. So let's just—that is to dispute the notion that if we were just connected to the grid everything would be fine. That is not necessarily true. But guess what? Wind didn't really work very well. It wasn't windy. Some of the turbines froze.

So it was actually producing about 6 percent of the total generation needed. That meant that coal, gas, nuclear had to provide an outsized amount. The problem wasn't underinvestments in that baseload energy. We have to accept that fact before we move on.

And then we have to accept the next fact: Our goal is to reduce carbon emissions, not just keep the oil in the ground. It is to reduce the carbon emissions because, we agree, it does have an effect on the climate in the long term.

So, Mr. Mills, I am going to ask you a set of very simple questions, and please provide simple answers.

Does the grid become more stable or less stable when more intermittent power sources are put into it?

Mr. MILLS. Less stable, but harder to manage.

Mr. CRENSHAW. It is certainly harder to manage.

Can solar or wind power the grid 100 percent of the time?

Mr. MILLS. There is no scenario where that is reasonably feasible at any price.

Mr. CRENSHAW. But they say they can put batteries in place. I mean, how many batteries would you need to do something like that?

Mr. MILLS. Can't build enough batteries. You could do other things. There are other forms of storage. They are all expensive. Pumped hydro is the cheapest, then compressed air. All cost more

money than storing oil in the ground, gas in the ground, or piles of coal near a power plant, by factors of 10 to 100.

Mr. CRENSHAW. Yeah. There are some interesting statistics on how much batteries would be needed. I think that Tesla's Gigafactory in Nevada can make 35 gigawatts of battery capacity each year. That would be 46 years of production to make up what Texas would have needed if we were on a 100 percent electrical grid.

Here is another question. Does our current permitting system even allow a wide-scale increase in building out things like transmission lines that would be required for this all solar/all wind kind of scenario?

Mr. MILLS. No, it doesn't. I think we need to fix a lot of things in the regulatory system, and NEPA itself is an impediment to an awful lot of different structure expansion, as everyone knows.

Mr. CRENSHAW. Can you make the materials that go into wind and solar without fossil fuels?

Mr. MILLS. No. The world's capacity to make mined minerals is dependent on oil, coal, and gas. The path to decarbonizing that sector is even longer than the path to, quote, "decarbonizing the grid."

Mr. CRENSHAW. And if America ceased all fossil fuel production, where would we get the raw materials and chemicals that go into everyday products—I mean, biomedical devices, our computers, our phones, literally everything that we use?

Mr. MILLS. Well, you are referring to the use of hydrocarbons or oil for petrochemicals.

Mr. CRENSHAW. Uh huh.

Mr. MILLS. Well, you could, in theory, synthesize them from biofuels. That is possible. That would require an expansion of epic proportions that no one can imagine doing and at great costs. Or you don't produce the stuff. You go back to using wood, leather, you know, glass, instead of plastics.

Mr. CRENSHAW. And, more importantly, if we don't produce them, somebody is going to produce them. So, if countries with poor environmental regulations produce these products——

Mr. MILLS. Correct.

Mr. CRENSHAW [continuing]. Do global emissions go up or do they go down?

Mr. MILLS. They go up. And they have been going up. In fact, we already know that the IEA has pointed out that the pursuit of greater mineral supplies for green energies is leading to higher energy use per unit of mineral produced and higher emissions. We are just exporting emissions.

Mr. CRENSHAW. Well, I am out of time. We could do this all day. Thank you, Mr. Mills.

Thank you, Madam Chairwoman. I yield back.

Ms. CASTOR. Rep. Casten, you are up next. You are recognized for 5 minutes.

Mr. CASTEN. Thank you, Madam Chair.

I am sitting here listening, and I have to be honest, I am just getting sad. We have real problems, the rest of the world is dealing with problems, and we are just having this conversation across party lines about fictions. If for the last 30 years one major political party had been screaming from the rooftop that two plus two

equals five, two plus two would still equal four. And yet here we are.

So, you know, I am in this lonely position as an devout free market environmentalist. And the reality—which I can't believe I even have to say this—is, what the private sector does is it finds a place to build low-cost stuff where they can sell it at a higher price.

And it has been a tremendous success since we deregulated our markets that the private sector did exactly that. It built all this low cost generation. The days of coal fired power are over because it is an economic dog. We don't have oil fired peakers anymore to any significant degree in the system because they are economic dogs. The simple cycle gas turbines are gone, the steam side gas turbines. That has been wonderful for consumers because it has all been squeezed out by stuff that is both cleaner and cheaper.

But it does create real problems. And we should be working on a bipartisan basis to break those real problems. Because we now are at a point where 40 percent of the U.S. power grid is being served—on a kilowatt hour basis, is being served by sources that have effectively no marginal operating cost, about half from renewables, half from nuclear. I am saying nuclear has no marginal operating cost because the fuel is more like a capital cost there. But it is creating this situation where wholesale markets are basically broke in this country.

We have lots of zero marginal cost generation, 40 percent of the whole market, that is a price taker, in a market that was designed to clear where supply and demand balance out. And so now we have markets that are going into negative prices for long periods, where it is confusing structures.

And this is a fixable problem. And it is a wonderful problem. We have caused huge value to flow to consumers. But the value is not flowing to investors. We are seeing in places like Illinois and Ohio where we have had political scandals because people are trying to say, can we get taxpayers to bail out the nuclear plants because ratepayers just aren't giving enough money to pay for them?

And so my question—and I will start with you, Ms. Hamilton, but I hope we have time for Ms. Sutley as well.

What kind of wholesale market reforms do we need to make sure that in a grid that is increasingly dominated by very low cost, sometimes zero-cost generation sources, we still have the incentives in place that are necessary to build the generation and the transmission to bring those to load?

Because our problem is not that power prices are too high; it is that they are too low.

Ms. HAMILTON. Thank you so much, Mr. Casten. And, unlike you, I am happy, not sad, because I see so many solutions out there, and I think it is completely doable. And I am also very much about markets and about, you know, free enterprise and making sure that you set up the right signals.

So the good news is FERC does have Order 2222, which is starting to be implemented right now, to try to bring in customer sited resources to actually be compensated for the value that they bring to the grid.

I think, as you mentioned, internalizing externalities like greenhouse gas emissions, like resilience, making sure that it is valued

and that that value is then passed along in the just and reasonable rates and market products that FERC then oversees.

So making sure that we actually set up all of those signals is incredibly important. And FERC is the perfect agency to do that because they build the record. They take evidence that is real and that they get from all kinds of stakeholders, and then they sift through the evidence, and they make decisions based on what is right for the customer.

And I think we are in a really good place right now, because I think we have those solutions. I think the private sector wants to come to the table, and the private sector wants nothing more than to deploy them and be compensated for what they can build.

Mr. CASTEN. Well, I am delighted to hear you say that, because, as you know, my Energy PRICE Act would actually direct FERC to do exactly that.

Ms. HAMILTON. Exactly.

Mr. CASTEN. Because they have got this issue: How are we going to deploy the right generation to get the incentives?

Ms. Sutley, any comments you want to add to that?

Ms. SUTLEY. Yeah, just a couple of things.

First of all, because we are a California utility, we actually do have to consider the price of carbon in our dispatch order, as well as basically paying for the carbon that is imbedded in any of our wholesale transactions. We are not FERC jurisdictional for our wholesale transactions.

The second that I would mention is, while we are not a member of the California ISO and we are not FERC jurisdictional, we do participate in a couple of the markets that have been established by the California ISO to address exactly the problem that you have mentioned. So we are participating in both the energy and balance market and the energy day ahead market. So, when that low-cost renewable or negative-price renewables are available, there is now a market in the West to take advantage of that. And we are glad to be a part of it.

Thank you.

Mr. CASTEN. Thank you.

And I see I am out of time. I yield back.

Ms. CASTOR. Thank you, Rep. Casten.

Next, Ranking Member Graves, you are recognized for 5 minutes.

Mr. GRAVES. Thank you, Madam Chair.

Mr. Casten, I think the concern is that folks have been out there declaring two plus two equals five, then legislating on the false narrative, which is even more concerning.

Mr. Mills, I wanted to ask you: Dan Brouillette, the former Energy Secretary, made a comment. He said, "America's energy and economic security, and therefore its national security, depends upon this vital flow of uninterrupted power. Modern civilization rests on the foundation that a resilient and secure electrical grid provides."

But you recently wrote in an article, California Governor Gavin Newsom issued emergency orders to procure more natural gas-fired electricity capacity to avoid blackouts. And in a possible sign of more such moves to come, earlier in the summer, California's elec-

tric grid operator 'stole' electricity that Arizona utilities had purchased that was in transit from Oregon."

Can you expand on that a little bit and just briefly summarize what happened there?

Mr. MILLS. I was——

Mr. GRAVES. And perhaps the implication on California's reliability to the grid?

Mr. MILLS. Thank you, Congressman. And I hope I used air quotes, as they say, over the word "stole" because——

Mr. GRAVES. Yes, you did.

Mr. MILLS [CONTINUING]. They were legally entitled to usurp the power that was in transit from hydro dams north of California to Arizona, which were contracted by the Arizona utility. I think those contracts will be written differently in the future by the two counter parties, recognizing that those clauses exist.

Look, California is an interesting state. You know, it imports, on average, over the year 30 percent of its electricity, according to the Cal ISO. So it is very dependent on the grid in the region for the availability of dispatchable power.

So the challenge in both transmitting power, whether it is from a hydro dam, which can be dispatched as long as you don't have a drought—you could dispatch power from a hydro dam, from a coal plant, from a gas plant, even from a nuclear plant. You can dispatch power from a battery.

But to keep lights on, the feature of the grid that is really important—and this is what California was dealing with—is they needed power at that particular moment that was coming across their lines contracted elsewhere, so they took it.

Arizona was able to survive the loss of that power, and they were paid for it, because they had access to other power which was dispatchable, which is sort of a key point I am making.

I happen to agree with Congressman Casten. We really are in desperate need for restructuring how we look at the electric grids, because marginal cost power does disrupt things, but recognizing how you price dispatchable power is also critical. We haven't done that either.

Mr. GRAVES. Thank you. Thank you.

Chair Sutley, nice to see you again. I worked with you in Louisiana, and I still run into Mike Boots every once in a while. I hope you are doing well.

I have a question. I know that the Los Angeles Department of Water and Power owns and imports its electricity from Intermountain Power Station in Delta, Utah. In total, 62 percent of Los Angeles' electricity comes from natural gas, nuclear, and coal. The coal plant has been L.A.'s single largest power source for about three decades, supplying one-third of the city's electricity——between one-fifth and one-third of the city's supply of electricity.

Now, your city has set a goal of 100 percent carbon free by 2035, but 27 percent of Los Angeles' power currently comes from natural gas. Looking at some of the high cost of electricity in Los Angeles already, what kind of costs are you going to thrust on your payers by forcing this conversion by 2035 to 100 percent carbon free?

Ms. SUTLEY. Thank you, Ranking Member Graves. And nice to see you too.

Well, first of all, with respect to the Intermountain Power Plant, it has served Los Angeles well for 30 years or more, but it is going to close in 2025. The original plan was to replace it with a smaller natural gas combustion combined cycle plant. And we have the contracts in place for combustion turbines that will burn up to 30 percent green hydrogen on the—or hydrogen on the day that they are turned on. So we expect Intermountain Power to continue to play an important role, just in a different way.

But——

Mr. GRAVES. But have you all run price models looking at the additional costs that your consumers will be impacted by?

Ms. SUTLEY. So, as part of the "LA100" study, the NREL did look at costs, and this is going to require significant investment.

They also pointed out that it was possible and probably advisable to ensure that we are investing in electrification of end users, because that will increase electricity sales and increase the number of customers' kilowatt hours that those costs are spread over. So that has a double benefit for our customers, both in terms of reduced air pollution but also in terms of mitigation of rate impacts.

So, right now, we are going through the financial analysis for our rates. We have not had a base rate increase in a number of years, and we are looking at that right now. But we continue to meet all our financial metrics and are looking at ways to ensure that we can do this transition in an affordable way.

Thank you for the question.

Mr. GRAVES. Thank you. Thank you very much.

And, Madam Chair, if you don't mind, I want to clarify something earlier. I heard you all raise concerns about comments made by Mrs. Miller, and I did want to just be very clear for the record: She did not say that anyone was anti-American. We went back and listened. She clearly stated that she was advocating for policies that were anti-American energy policies, so, in other words, anti-domestic energy production. And I wanted to be clear that——

Ms. CASTOR. Hey, we are all about domestic energy in this hearing today, so——

Mr. GRAVES. Okay. I just wanted to be clear that nobody was called anti-American and that she did clearly say anti American energy. So I just wanted to clarify that to make sure that there was no ill will among committee members.

Ms. CASTOR. All right. Thank you——

Mr. GRAVES. Thank you.

Ms. CASTOR [continuing]. Ranking Member Graves.

Next, we will go to Rep. Neguse.

And I have to say, Rep. Neguse, we are still thinking about all of your neighbors, that the wildfires that swept through the Boulder area are still very fresh in everyone's minds. And you are recognized for 5 minutes.

Mr. NEGUSE. Well, thank you, Madam Chair, first, for holding this important and timely hearing on ensuring the reliability and the resiliency of our electric grid, and also for your very kind words and, of course, the words that I have heard from colleagues on both sides of the aisle over the course of the last few months as we have dealt with a very difficult series of fires here in our community. I certainly appreciate it, as does my community.

And as you noted, Chairwoman Castor, my district in Colorado has experienced some of the most devastating wildfires in the history of our state, all over the course of the last 15 months, from the Cameron Peak and East Troublesome Fires in 2020 that were the first and second largest fires in state history, to the most recent Marshall Fire that destroyed more than 1,000 homes and became the most destructive fire in our state's history.

And many of you traveled to Colorado for the field hearing that we held in Boulder over 2 years ago, pre-pandemic, and during that hearing had an opportunity to visit these same communities that have now been besieged by wildfires. So many homes destroyed in the blaze that occurred on December 30th, which is far later than what would be typically considered fire season.

And as we have frequently discussed in this committee, climate change is only increasing the severity and the frequency of extreme weather events and natural disasters like wildfires and, as I said, has caused I think all of us, collectively, to reconsider what we previously considered to be fire season. It clearly now goes all year long here in Colorado and across the Rocky Mountain West.

And we have to ensure that our infrastructure is prepared for these events, which is why today's hearing is certainly so critical for me.

It is also why we introduced with Senator Wyden last year the Disaster Safe Power Grid Act. I was glad to see some of the investments that we called for in that bill included in the Infrastructure Investment and Jobs Act, or the bipartisan infrastructure law, to ensure our electric grid infrastructure is prepared to withstand future disasters and wildfires. And I appreciate the conversation about the particular benefits of that bill that Chair Castor noted and articulated earlier during the course of today's hearing.

I want to talk about a particular issue that is certainly percolating here in our community as a byproduct of the Marshall Fire and the rebuilding process that we are now deeply engaged in. It is important that we support efforts to build back better in the wake of disasters like those that my district experienced, and we are working hard on those efforts right now, particularly in the wake of the Marshall Fire.

Ms. Hamilton, you have talked a bit about this during the course of the hearing but also in your written testimony, about the importance of directly investing in physical structures, such as homes and buildings, to reduce the risk of damage during a natural disaster.

I wonder if you might be able to expound a bit on whether you think the Federal Government should provide incentives for homeowners to rebuild zero or lower-emission homes with electric appliances and equipment after disasters and how you believe that might help fight the climate crisis.

Ms. HAMILTON. Absolutely. That is such a great question, because often everything stems from the home, and, you know, what do we need to make those resilient? So making sure that the insulation is strong, that the roofing is strong.

In fact, there is an organization in Florida called the Solar Energy Loan Fund that has found that, if they harden the roof, it reduces—this is in the case of hurricane, but it could certainly hap-

pen with any natural disaster—if they harden the roof, they are able to put solar on, reduce insurance costs that then pay for the solar.

This can happen in communities all over in very different ways. In Louisiana, the company PosiGen does, first, energy audits and then installs solar, so that immediately you can start seeing the benefits of reduced energy costs, while making sure that you have that power—if you install solar and you have a backup battery, you will have the power there in case of any kind of fire.

But, even more importantly, Mr. Neguse, is we need to plan. We need visibility. We need technologies that allow us to understand when something is going to happen, whether that is on the transmission side or the distribution side, and be able to react in a resilient way and plan for these instances.

So maybe not everybody is going to be able to withstand an instance like this, but maybe you can have community centers—microgrids that allow communities to continue running really critical facilities for neighborhoods so that there is someplace to go in case of an event like this.

Mr. NEGUSE. Well, your insights are certainly very helpful. And our office is very interested in pursuing this further and potentially introducing legislation on the same, in terms of Federal rebates that might be brought to bear for consumers.

And I see that I am running out of time. Dr. Wayland, I would just say I very much appreciated your testimony, in particular the smart technologies that you described that can predict problems on transmission lines before they can start wildfires.

We recently had a wildfire in the northern part of my district, far smaller, but in Estes Park, that was caused in part by a downed power line. And it is clear that those smart technologies are crucial for my communities, for communities across the State of Colorado and, indeed, across the Rocky Mountain West, as wildfires become more pervasive here. So I look forward to continuing to work on that issue as well.

And, with that, I yield back the balance of my time, Madam Chair.

Ms. CASTOR. Thank you, Rep. Neguse.

And thanks to all of our witnesses for your outstanding testimony today.

I am going to go to the Ranking Member, if he wants to make a unanimous consent request.

Mr. Graves, Rep. Graves, do you have any documents——

Mr. GRAVES. Yes, ma'am.

Ms. CASTOR [continuing]. For the record?

Mr. GRAVES. I have two documents.

Number one is a EIA report titled "Oil fired generators helped meet electric demand in New England this January." And the second one is "Big but affordable effort needed for America to reach net-zero emissions by 2050," which is a Princeton study, and just talking about two of the issues that I cited earlier.

So I would ask unanimous consent that those be included in the record.

Ms. CASTOR. All right. Without objection.

[The information follows:]

Submissions for the Record
Representative Garret Graves
Select Committee on the Climate Crisis
February 15, 2022

ATTACHMENT: Brown, M. Tyson, "Oil-fired generators helped meet electric demand in New England this January," U.S. Energy Information Administration (EIA), 2022, 10 February.
This report is retained in the committee files and available at:
https://www.eia.gov/todayinenergy/detail.php?id=51238
ATTACHMENT: : E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, *Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Final report*, Princeton University, Princeton, NJ, 29 October 2021.
This report is retained in the committee files and available at:
https://netzeroamerica.princeton.edu/the-report

Ms. CASTOR. And, without objection, I would like to enter into the record a February 2022 report from Grid Strategies titled "The One Year Anniversary of Winter Storm Uri: Lessons Learned and the Continued Need for Large Scale Transmission"; two, a July 2021 report from the American Council on Renewable Energy and the Macro Grid Initiative titled "Transmission Makes the Power System Resilient to Extreme Weather"; and, three, a February 2022 report from Environment America titled "Rooftop Solar and the 2021 Texas Power Crisis: Exploring Small Scale Solar's Potential to Improve Grid Resilience During a Deep Freeze Event."

[The information follows:]

Submissions for the Record
Representative Kathy Castor
Select Committee on the Climate Crisis
February 15, 2022

ATTACHMENT: Goggin, M. and Schneider, J., *The One-Year Anniversary of Winter Storm Uri: Lessons Learned and the Continued Need for Large-Scale Transmission*, Grid Strategies, 2022, 13 February.
This report is retained in the committee files and available at:
https://gridprogress.files.wordpress.com/2022/02/the-one-year-anniversary-of-winter-storm-uri-lessons-learned-and-the-continued-need-for-large-scale-transmission.pdf
ATTACHMENT: Goggin, M., T*ransmission Makes the Power System Resilient to Extreme Weather*, Grid Strategies, American Council on Renewable Energy (ACORE), and the Macro Grid Initiative, 2021 July.
This report is retained in the committee files and available at:
https://acore.org/wp-content/uploads/2021/07/GS_Resilient-Transmission_proof.pdf
ATTACHMENT: Searson, E., Dutzik, T., and Huxley-Reicher, B., *Rooftop Solar and the 2021 Texas Power Crisis: Exploring Small-Scale Solar's Potential to Improve Grid Resilience During a Deep Freeze Event*, Environment America Research & Policy Center and the Frontier Group, 2022 February.
This report is retained in the committee files and available at:
https://environmentamericacenter.org/sites/environment/files/reports/Rooftop%20solar%20and%20the%202021%20Texas%20power%20crisis.pdf

Ms. CASTOR. You know, this was a very important hearing. And I think we again have to let the American people know that we hear you. We are overwhelmed, watching these climate fueled disasters, whether it is the deadly winter storm in Texas or floods in the Midwest, like Tennessee,—or I see Rep. Bonamici—the deadly heat wave in the Pacific Northwest, the wildfires everywhere, and we are doing something about it.

Thankfully, this bipartisan infrastructure law gives us new resources to work with the Biden administration to make our grid more reliable and resilient. And if we can now work to expand clean energy and reduce pollution, create jobs, and lower costs for consumers, that is what we aim to do here.

So thank you all for participating in this hearing.

And the committee hearing is adjourned.

Thank you.

[Whereupon, at 4:35 p.m., the committee was adjourned.]

United States House of Representatives
Select Committee on the Climate Crisis

Hearing on February 15, 2022
"Keeping the Lights on:
Strategies for Grid Resilience and Reliability"

Responses to Questions for the Record

The Honorable Nancy Sutley
Senior Assistant General Manager of External and Regulatory Affairs
Chief Sustainability Officer
Los Angeles Department of Water & Power

THE HONORABLE KATHY CASTOR

1. **From your perspective at LADWP, could you please describe the costs of inaction on climate change? How would capital investments now to help transition to 100% clean energy by 2035 achieve greater benefits for your service territory as compared to the status quo?**

The negative impacts of climate change include, but are not limited to, the ability of LADWP to maintain resource adequacy, rising temperatures increasing customer electricity demand, accelerated degradation of critical transmission/distribution equipment resulting in more frequent outages, and our ability to serve load during transmission outages which may become more frequent due to wildfires. The cost of inaction on climate change would be the continued adverse health effects on the citizens of Los Angeles from PM2.5 and NOx emissions due to a lack of investment in significantly decarbonizing the transportation sector. Climate change is also affecting water supply in Los Angeles—we are experiencing more frequent and longer drought cycles.

These impacts led to action by state and local government entities and the investment in the Los Angeles 100% Renewable Study (LA100) completed in March 2021, in partnership with the National Renewable Energy Laboratory (NREL). The LA100 Study analyzed and quantified the capital investments necessary for transitioning to 100% carbon free by 2035 to achieve greater benefits for LADWP's service territory, relative to the status quo to meet the requirements of California Senate Bill 100 and avoid these costs of inaction.[1] As discussed in my testimony, the LA100 Study evaluated multiple pathways and costs to achieve a 100% renewable electricity supply. The study considered electrifying key end uses while maintaining a high degree of reliability, quantified the reductions in GHG emissions contributing to climate change and local air quality and resulting health impacts. It also evaluated the economic and employment impacts to our community.

Through a zero-carbon electricity grid, LADWP will help spur decarbonization efforts across multiple end users, including the transportation and building sectors. Significant capital investments to enable LADWP's vision of becoming a carbon free utility by 2035 will yield several benefits, including, but not limited to, reducing greenhouse gas emissions, improving local air quality, and providing clean electricity to fuel transportation and buildings.

2. **The United States is blessed with affordable and abundant renewable energy resources, but they are often located far away from densely populated cities. Upgrading and expanding our electric grid could**

[1] https://www.nrel.gov/analysis/los-angeles-100-percent-renewable-study.html

help ensure that every American can access clean energy. The Biden Administration has already launched an initiative to use existing rights-of-way to site transmission to make this easier. In your testimony, you mentioned the need for transmission investments.

a. How would Federal investments to upgrade and expand transmission help LADWP improve electric grid reliability and resilience as you transition to 100% clean energy?

Federal investment can assist in bringing renewable resources to load centers. Renewable energy resources, for the most part, are resource dependent and location specific. Federal investments would help meet the need to expand transmission system to access low-cost renewable energy resources. To transition to 100% renewable energy resources, LADWP will consider two critical elements as part of its strategic transmission plan:

- Siting a variety of resources in diverse regions to ensure reliability during unfavorable weather conditions.
- Funding for multiple transmission corridors to increase operational flexibility and to minimize the risks caused by system failure, wildfires, and other unforeseen events.

As such, using Federal investments would enable LADWP to meet those two elements by upgrading existing transmission corridors making the system more efficient and reliable. It will also create an opportunity for increased economic, environmental, and consumer benefits as we thrive toward 100% clean energy.

b. How would upgrading and expanding the electric grid help consumers save money on electric bills?

As a publicly owned utility, our focus is on delivering reliable, cost-efficient electricity while also transitioning the generation mix to decarbonized resources. Upgrading and expanding the electric grid on various levels—transmission, sub-transmission, and distribution—increases access and delivery of low-cost renewables and energy storage resources outside of LADWP's service territory, and provides access to customer-side, distributed energy resource options for customers to save money on their bills (e.g. local solar, demand response, and energy efficiency).

Bolstering the electric grid to support widespread adoption of transportation and building electrification also translates to overall customer cost savings by increasing electricity sales that can cover more of the fixed costs to support the delivery of electricity resulting in lower electricity rates.

To meet the growing need, LADWP must upgrade at least ten (10) major internal transmission lines with the LA Basin over the next 10 years, expand the in-service ratings of several existing lines, and coordinate with other utilities and private developers to obtain access to renewable and storage resources. To date, LADWP has worked with developers and successfully entered into power purchase agreements for some of the largest and most cost-effective renewable energy and energy storage projects in the country.

c. How would the Bipartisan Infrastructure Law and the initiative to use existing rights-of-way facilitate transmission development without compromising environmental protections?

The use of existing transmission infrastructure to pivot from fossil fuel generation to renewable energy integration will be vital in reaching the 100% clean energy goals. Implementation of the Bipartisan Infrastructure Law (P.L. 117–58, Bipartisan Infrastructure Law) aims to accelerate building and upgrading thousands of miles of transmission lines to improve reliability, reduce energy costs and facilitate the expansion of clean energy. LADWP has initiated that process with such programs as the Intermountain Power Project (IPP) through the upgrade of the associated High Voltage Direct Current (HVDC) Southern Transmission System (STS). This upgrade is required due to the IPP generation facility transitioning from large base-load coal units to green hydrogen/natural gas generating units, allowing greater integration with variable renewable energy in the Utah area and transmitted to the greater Los Angeles area.

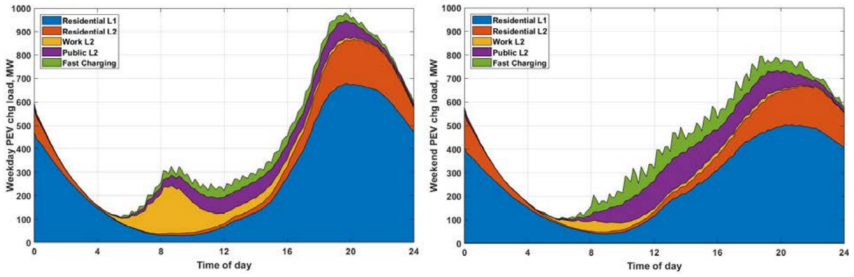
The Bipartisan Infrastructure Law's ability to make funds, grants, and investment assistance available to support these conversions, in addition to assisting in streamlining the permitting process, will move the resiliency and reliability of transmission systems at a much quicker pace. Additionally, with some of these resources, we hope that the Power Marketing Agencies will upgrade their transmission systems.

3. Energy efficiency is a critically important near-term strategy because it can help Americans save money on their household energy bills and on their transportation fuels as well as reduce carbon pollution. In your testimony, you highlighted the Comprehensive Multifamily Retrofit program for deep energy savings for residents living in multifamily units. Could you please help us understand how energy efficiency also helps improve grid reliability and resilience to power interruptions and other disruptive events?

We agree, energy efficiency (EE) saves customers money on their electric bills and helps manage the peaks and base load generation.

LADWP anticipates that the electrification of the transportation sector will grow demand and EE is a cost-effective way to balance the system. With careful planning & targeted EE efforts, these anticipated effects may be mitigated. The visual below demonstrates how EE may counter the effects of Building Electrification (BE) load growth in the residential sector and interactions of various layers of Distributed Energy Resources (DER) to the distribution system. Specifically, these graphs demonstrate that additive properties of EE & DR in load constrained areas yield beneficial results. The avoidance of overloading the system capacity and avoidance of grid interruptions provides for a more reliable and resilient grid.

PEV Charging Loads (weekday/weekend)



Source: CEC & NREL

Furthermore, EE efforts, in the way of incentives, outreach, education and community partnerships, raise awareness and accelerate consumer adoption of new technologies that enable connected demand responsive/flexible load appliances and devices within the household. For example, the introduction of economic incentives for Smart Thermostats resulted in increased adoption rates. Demand Response (DR) programs provide the ability to reduce demand during system wide high peak periods.

EE is a fundamental part of LADWP's DER strategy and will continue to be innovated/optimized over time to maximize its benefits to customers and the utility in its efforts to increase reliability of its grid services.

4. In your testimony, you referenced a grid resilience project at the Green Meadows Recreation Center in South Los Angeles that provided solar panels, energy storage, and EV charging in a disadvantaged community. In your view, how would the EV charging investments in the Bipartisan Infrastructure Law help achieve LADWP goals?

The programs funded or created in the Bipartisan Infrastructure Law will help LADWP meet decarbonization goals, strengthen equity initiatives and reduce transportation-related emissions. More details on these goals are:

- Federal investments—including investments in clean energy and energy efficiency, clean transit, and pollution reduction—help LADWP reduce carbon and other tailpipe emissions, improving air quality for the entire region.
- The Bipartisan Infrastructure Law will help accelerate the adoption of and confidence in electric vehicles, including for those who cannot reliably charge at home

Additional resources, through the Bipartisan Infrastructure Law, help support the development of convenient, accessible, reliable, and equitable EV charging.

- The Bipartisan Infrastructure Law helps achieve LADWP goals by further reaching the needs of historically marginalized and underserved communities within our service territory.

- Federal funding can help bring opportunities for innovative financial and technological solutions to increase access to home charging in multi-family residences and community-based charging solutions in underserved areas, including disadvantaged communities. Federal funding helps achieve quantifiable improvements in EV adoption, charging access, reliability, and consumer confidence in EVs.

5. In your testimony, you discussed Federal financing tools for clean energy and resilience investments. Could you please describe how the Federal government can encourage more private sector investment in electricity infrastructure that is clean, reliable, and resilient?

LADWP supports efforts to develop legislation to preserve tax-exempt financing (i.e., the exclusion of interest for state and municipal bonds from taxable income) and the restoration of the ability to issue tax-exempt advance refunding bonds. Advance refunding is an important tool for municipal utilities to lower borrowing costs associated with infrastructure development, which results in lower electric rates in the communities that we serve. On the customer asset side, providing funding or tax incentives for manufactures to develop vehicles, trucks, and potentially electrify existing trainlines to transport people and goods would help customers adopt and adapt to having transportation assets, normally powered by gasoline, change to electricity.

One other area discussed in the past is expanding the utilization of large hydroelectric plants, such as Hoover Dam, to create a pump storage system that allows for additional clean dispatchable energy. While the engineering to create the system can be accomplished several ways, there is a lack of water that comes down the Colorado River into Lake Mead that presents a significant challenge. If the Federal government was able to capture the storm water east of the Colorado River that ends up going out to the ocean and direct it into the Colorado River, increasing clean energy from Hoover Dam could be feasible.

6. How would American companies benefit from the Section 48C incentive to manufacture climate solutions in this country?

Some critical power-related components are not manufactured in the U.S., forcing utilities, including LADWP, to rely on imported components when they are making investments in their power infrastructure. Limited availability and increased prices of these foreign-sourced components can cause delays to utility modernization projects resulting in increased costs to ratepayers. Incentivizing the domestic production of advanced electric grid, energy storage, fuel cell equipment, as well as renewable energy and energy efficient equipment helps secure a resilient power grid at lower costs to ratepayers. It can also address the need for high-skilled jobs here at home. These benefits extend beyond the electric grid to manufacturing of advanced light-, medium- and heavy-duty vehicles and components that will be powered by the electric grid. These incentives help reduce risks that would result from reliance on foreign components, while making American components more cost competitive.

7. Could you please describe the state of California's efforts to improve grid resilience? How could Congress complement these efforts?

California's utilities, grid operators, and communities face heightened risks from climate change, most prominently due to increasingly frequent and destructive wildfires, as well as threats like extreme heat events. These impacts jeopardize the state's energy infrastructure, prompting a robust effort to improve the resiliency of the electrical grid. A range of technologies and programs have been promoted to increase clean energy integration, grid reliability and community resilience in the face of these climate change-related risks. These solutions include microgrids, distributed renewable generation, energy storage, building energy management systems, building performance and load flexibility and vehicle-grid integration.

California regulators such as the California Public Utilities Commission (CPUC), the California Energy Commission (CEC) and legislators have implemented programs to support resiliency technologies such as the deployment for microgrids and battery storage, a Self-Generation Incentive Program (SGIP), required wildfire mitigation plans, focus on lower-income communities that face particular barriers to energy resilience and Title 24 building energy efficiency standards requiring new residential construction to include rooftop or community solar installations.

LADWP has utilized these state programs to make the portions of the grid we manage and maintain more resilient. We propose Congress can complement California's efforts with the following:

- Establish a reliability standard, within the Federal Power Act that addresses resiliency related to extreme weather events;
- Create a program through the Department of Energy (DOE) to advise and be a resource for states and local utilities on ways to improve the resiliency of their electrical grids; making funds, grants, and investment assistance available to support resiliency projects;
- Fund and prioritize emerging grid and community resilience technologies and pilot projects; and,
- Publish a Department of Energy report that provides recommendations on how to minimize planned electric power outages due to extreme weather conditions.

8. High-voltage direct current transmission lines could help connect transmission interconnections and transmission regions, which would allow more Americans to access clean energy. What Federal investments could ensure that these HDVC transmission lines are themselves resilient to the unavoidable impacts of climate change?

LADWP is the only utility in the Western grid that operates two High Voltage Direct Current (HVDC) links to import energy from remote locations to load centers. Those HVDC systems were built based on technologies from the early 1980s. Over the years, HVDC systems have significantly improved due to research and development of emerging technologies. New HVDC systems are robust, reliable, and better suited for transmitting renewable energy resources.

For those reasons, LADWP is highly interested in adding additional HVDC in its transmission system to access remote and low-cost renewable energy. To ensure that new HVDC systems are resilient to the unavoidable impacts of climate change, the following investments should be considered:

- Weatherization of HVDC systems to weather extremities such as induced-climate change extended-heat wave
- Redundant devices such as thyristors in the series string composing a HVDC valve, so that thyristor failures can be replaced in timely manner
- Double pole HVDC system which provides a high level of reliability simply because the failure of one pole does not affect the operation of the other pole
- Adequate overload rating on DC conductors to ensure that the pre-contingency power level can be maintained even with permanent outage of one pole

9. Why is it important for the federal government to invest in recycling and reuse of critical minerals that are important inputs to batteries and other clean energy technologies? For instance, the Bipartisan Infrastructure Law invests $7 billion in critical mineral supply chains, including a $140 million program recently announced by the Department of Energy to develop a first-of-a-kind refinery to extract rare earth elements from coal ash waste. How could these efforts complement new mining and processing domestically and around the world?

We are encouraged by efforts such as California's Lithium Valley Commission to produce, protect, recycle and reuse critical minerals.

10. In your view, could you please describe how California can maintain grid reliability even as the state and the Western part of the country transition to a clean energy economy? What role would strategies like expanding transmission, investing in grid-scale energy storage, and expanding the use of distributed energy resources play?

Expanding transmission, investing in grid-scale energy storage, maintaining firm capacity near the load center, and expanding the use of distributed energy resources, in combination, all contribute to LADWP reaching its goal of a 100% clean energy future. All LA100 scenarios were evaluated to ensure that LADWP can balance demand for electricity with supply, even after failures of transmission and generation equipment or other extreme events occur. While wind and solar technologies provide a large fraction of the energy needs, all scenarios rely heavily on storage with less than 12 hours of duration, demand response, renewably derived fuel like green hydrogen, to provide sufficient operational flexibility and operating reserves as required by NERC/WECC operating standards. As LADWP expands its resource mix to 100% clean energy by expanding transmission and renewable energy further from the load center, it must also maintain firm capacity near its load center (~300

hours of duration) in the face of extreme events such as wildfires, or consecutive days with low renewable production.

THE HONORABLE GARRET GRAVES

1. **In our hearing, you acknowledged that Los Angeles' goal to become 100 percent carbon-free by 2035 will "require significant investment." You also indicated that Los Angeles Department of Water and Power is currently conducting financial analysis of those plans. Further, the NREL report that you cite in your testimony states, "the estimated total cumulative costs of new investments needed to achieve the 100% target across the suite of scenarios explored range from $57 billion to $87 billion (in 2019 dollars) depending on the scenario and load projection."[2] Even this astronomical cost projection is not all inclusive. NREL excluded some critical elements such as: future operating costs for the distribution grid; distribution upgrade costs beyond equipment and labor, including land acquisition costs for substation expansion; new substations; or circuit reconfiguration. And costs associated with customer programs, for example, to support energy efficiency or encourage demand response.**

   - **Can you say for certain that Los Angeles' plans to restructure its power grid between now and 2035—a grid that currently relies on 27% of its power from natural gas[3]—won't result in rate increases for your customers?**

To determine the rate impacts, LADWP is currently determining rate options through the upcoming 2022 Strategic Long-Term Resource Plan (SLTRP). The LA100 Study indicated that 100 percent renewable pathways could be implemented cost effectively and largely in-line with inflation. This determination relies on aggressive transportation and building electrification growth, sufficient to support investment costs through increased retail sales, which we are well on the path to implement. LADWP's mission is to provide our customers and the communities we serve with safe, reliable, and cost-effective water and power in a customer-focused and environmentally responsible manner and we must balance these multiple objectives while giving consideration to cost.

   - **If it will result in increased costs to consumers, has that been communicated to the citizens of Los Angeles?**

Through the LA100 Study and through 2022 SLTRP Advisory Group process, LADWP has consistently communicated its plan development, which ultimately will provide the total power system investment cost and rate impacts in the near term, through 2045. Consistent with its planning practices, LADWP also intends to hold public outreach workshops in mid-2022 to further communicate the costs and benefits to customers as part of the SLTRP. LADWP has also launched the LA100 Equity Strategies Initiative, which is a stakeholder-driven effort to identify community driven, energy-just outcomes, particularly for those in disadvantaged communities, as LADWP transitions to 100% clean energy.

LADWP rate setting is a public process. LADWP must consult with LA's neighborhood councils representing more than 100 communities within Los Angeles. The Board of Water and Power Commissioners considers any rate actions, which then go to Los Angeles City Council and ultimately to the Mayor of Los Angeles for final approval. Rate setting must meet the requirements of Los Angeles City Charter, as well as criteria in the California Constitution regarding local government revenue.

2. **In your written testimony, you stated, "Through the remainder of this decade, Los Angeles' goals include providing an energy mix that is 80 percent renewable and 97 percent carbon-free resources by *2030* on the way to a 100 percent clean energy grid." According to the Intermountain Power Agency's website, net generating capacity will be 840 megawatts.[4] The website also states that, "the new natural gas gener-**

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[2] https://www.nrel.gov/docs/fy21osti/79444-ES.pdf

[3] https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-factandfigures;jsessionid=QMggvdfRX3jhfs1KrXgFdDmWKn3k822QWJkyhlfg1njs1sLrvZlN!1901012332?_afrWindowId=null&_afrLoop=478600879122470&_afrWindowMode=0&_adf.ctrl-state=1aplkups2b_59#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D478600879122470%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dfm29dp575_4

[4] https://www.ipautah.com/ipp-renewed/

ating units will be designed to utilize 30 percent hydrogen fuel at start-up, (in 2025) transitioning to 100 percent hydrogen fuel by 2045 as technology improves."[5] Finally, the National Renewable Energy Laboratory (NREL) study you mention in your testimony states, "These aspects of the SB100 scenario allow for 10%–15% of power generation to be derived from natural gas. As a result, this scenario allows some of the existing natural gas plants to stay active in 2045."[6] Today, Los Angeles Department of Water and Power depends upon 62% of its electricity needs from reliable sources, such as natural gas and coal.[7] Note that over 25% of your current production is met by coal powered generation coming from the Intermountain plant in Utah. It seems that you will need to continue to use fossil fuels well past the 2035 date you stated.

- **Can you explain how Los Angeles will be 100 percent carbon free by 2035?**

The City of Los Angeles has set ambitious goals to transform its energy supply. LADWP partnered with the National Renewable Energy Laboratory (NREL) on the LA100 Study, a first-of-its-kind objective, highly detailed, rigorous, and science-based study to analyze potential pathways the community can take to achieve a 100% clean energy future. While 3 of the 4 key scenarios identified shows LADWP reaching 100% clean energy by 2045, the Early & No Biofuels scenario outlined a pathway to reach the 100% carbon-free goal 10 years sooner by 2035. This scenario was evaluated under moderate and high load electrification, included no natural gas generation or biofuels, and allowed for use of existing nuclear resources and upgrades to transmission.

LADWP has amended the long-term power sales agreement to stop taking coal power from the Intermountain Power Project (IPP) no later than 2027, as required by California Senate Bill 1368, and has plans to accelerate that date to no later than 2025. IPP will be converted from a 1,800 MW coal-fired power plant to an 840 MW combined cycle gas turbine capable of using a blend of natural gas and 30% green hydrogen upon commissioning in 2025. The combined cycle gas turbine will then be converted and will operate on 100% green hydrogen when the technology is available. In parallel, LADWP will be procuring the renewable resources and will facilitate the purchase of electrolyzers and fuel storage to support green hydrogen at IPP. The IPP Operating Agent is working closely with the turbine manufacturer and they have optimistic hydrogen glidepaths for significantly increasing the hydrogen capability in the 2030s timeframe. The technology maturity must move in lock step in order for LADWP to achieve its 100 percent carbon free goal by 2035.

LADWP will build upon the LA100 Study outcomes, and is assessing the implementation feasibility of achieving 100% carbon free by 2035. To that end, the 2022 SLTRP will be expanded to address implementation feasibility, assess technology innovation, and include an Integrated Human Resources Plan to help achieve its goal.

THE HONORABLE VERONICA ESCOBAR

1. **How can local governments work with utilities to advance environmental justice and how can the Federal government support that?**

LADWP works to coordinate, build partnerships, and collaborate with local, state, and federal government agencies to streamline and overcome opposition, legal challenges and hurdles that may prohibit LADWP's ability to advance environmental justice through traditional mechanisms.

In addition, funding for power programs in the form of loans, grants, incentives, cooperatives, agreements, and/or credit allocations could vastly improve LADWP's ability to target funding of its programs towards disadvantaged communities.

LADWP has also launched the LA100 Equity Strategies Initiative, which is a stakeholder-driven effort to identify community driven, energy-just outcomes, particularly for those in disadvantaged communities, as LADWP transitions to 100% clean energy. We expect the results of this study to be finalized by the end of 2023.

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[5] *Ibid*.

[6] https://www.nrel.gov/docs/fy21osti/79444-ES.pdf

[7] https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-factandfigures;jsessionid=QMggvdfRX3jhfs1KrXgFdDmWKn3k822QWJkyhlfg1njs1sLrvZlN!1901012332?_afrWindowId=null&_afrLoop=478600879122470&_afrWindowMode=0&_adf.ctrl-state=1aplkups2b_59#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D478600879122470%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dfm29dp575_4

Questions for the Record

Dr. Karen Wayland
Chief Executive Officer
GridWise Alliance

THE HONORABLE KATHY CASTOR

1. The United States is blessed with affordable and abundant renewable energy resources, but they are often located far away from densely populated cities. Upgrading and expanding our electric grid could help ensure that every American can access clean energy. The Biden Administration has already launched an initiative to use existing rights-of-way to site transmission to make this easier.

a. How would upgrading and expanding the electric grid help your members improve electric grid reliability and resilience as we transition to a clean energy economy?

The electric grid has been providing reliable and affordable electricity for over 100 years. However, the grid was designed for one-way flow of electricity from centralized generating units through the transmission and distribution systems to the customer. With the incorporation of distributed energy resources and highly digitized technologies, the grid now must accommodate two-way flows of energy and information. Upgrading and expanding the grid is critical to ensure more secure, resilient and efficient delivery of a necessary service.

To balance electricity supply and demand, especially as more renewable energy comes on-line, the grid must have system flexibility, which can be provided by a mix of supply- and demand-side options, including flexible conventional generation, curtailment of renewable generation, new transmission, and more responsive loads.[1] Grid technologies like controls, sensors, storage, data analytics and software-as-service (SAS) can provide flexibility by improving visibility of the system for grid operators, helping to quickly rebalance the system with autonomous controls, and facilitating the aggregation of distributed energy resources to serve as assets to grid operations. These technologies help integrate utility-scale and distributed renewables, can relieve transmission constraints and reduce the need for peak generation. These flexibility technologies also build resilience by providing back up power, automatically rerouting power around damaged lines, and self-healing grid damage.

b. How would upgrading and expanding the electric grid help consumers save money on electric bills?

Upgrading and expanding the grid allows for more effective and efficient delivery of electricity. These efficiencies are passed on to consumers. Modern grid technologies also significantly improve resilience to severe weather disruptions, which then reduces the number and duration of outages and speeds recovery. Outages have human and dollar costs for consumers, so grid modernization investments that improve resilience will save consumers money, not only on their electric bills. Most utilities in the United States have adopted energy efficiency programs as part of the services they provide but more needs to be done in the form of energy education. Most consumers have no idea how they use, generate and store energy. Technologies like Advanced Meter Infrastructure (AMI) can provide better transparency and education for consumers, but must be supported and enabled by the regulatory entities.

c. How would the Bipartisan Infrastructure Law and the initiative to use existing rights-of-way facilitate transmission dev out compromising environmental protections?

The GridWise Alliance has not studied the impacts of rights-of-way policies in the Bipartisan Infrastructure Law or how developing new transmission in these rights-of-way would be treated under state or federal environmental statutes.

2. Energy efficiency is a critically important near-term strategy because it can help Americans save money on their household energy bills and on their transportation fuels as well as reduce carbon pollution. Could you please help us understand how energy efficiency also helps improve grid reliability and resilience to power interruptions and other disruptive events?

[1] https://www.nrel.gov/docs/fy16osti/64764.pdf

Buildings consume 76% of electricity generated in the United States.[2] IIJA includes significant funding for weatherization and energy efficiency improvements for federal, residential, and commercial buildings through updated building codes, funding for building retrofits, state energy grants, and other policy levers. Improving the efficiency of the nation's building stock will enhance resilience to energy disruptions in addition to saving energy. Well-insulated buildings reduce heating and cooling load during periods of high electricity demand associated with extreme weather and keep occupants more comfortable during power outages. Focusing resources for weatherization on underserved and low-income communities is critical to ensure that those populations do not suffer disproportionately during energy disruptions. IIJA funding will result in the weatherization and retrofitting of millions of public and private buildings across the country.

In my testimony I provide a dramatic example of how energy efficiency at the household level improves grid reliability as well as the consumer experience. GridWise member Bandera Electric Cooperative (BEC) in Texas has deployed technology to analyze energy use at the appliance level, allowing granular visibility into how the grid functioned during and after Winter Storm Uri, the 2021 freeze and described how households were affected in a paper entitled, "What was happening inside Texas homes during the February 2021 freeze?"[3] In this paper and a submission to the Public Utility Commission of Texas (PUCT, Docket 52373), BEC described the impact of energy efficiency on grid reliability and affordability. Average home power draw was almost 500% higher and average HVAC power demand 620% higher during the period of February 11–20 compared to February 1, 2021. However, the kWh/sqft of homes monitored by Apolloware varied by a factor of 21, meaning some homes were more cold-sensitive and used more energy the colder the outside temperatures relative to other homes.

Energy efficiency is good for the grid and consumers. Through adoption of technologies where consumers can see their energy usage in real time you are providing them actionable information to conserve and reduce energy. This is the first step in education and awareness. Numerous technical papers and research shows that consumers who are aware of the energy usage in real time save about 22% on their energy bills. This is accomplished by changing behavior. In Texas following Winter Storm Yuri, BEC saw firsthand how providing consumers information during the event dramatically changed their behavior. Technologies exist today that if adopted and utilized would reduce the number of power interruptions during disruptive events. This is how energy efficiency technologies can reduce power interruptions, reduce energy costs and thereby improve grid resiliency and reliability.

While the weather in Texas on Feb 3–6 of 2022 was not as severe as 2021, Bandera experienced only 10 outages and was able to utilize energy analytics to provide better transparency of real time energy usage to its customers. In its submission to the PUCT in November 2021, BEC concluded that "Having granular individual data tied to substation, feeder and phase is an important aspect of understanding energy use tied to weather . . . Having behind the meter visibility and transparency would help ERCOT with better grid planning and more importantly better understanding of how to minimize black-outs through the development of an intelligent demand response program based on fleet wide monitoring and control of HVAC, Water Heaters and Pool pump devices ties to wholesale market prices. If this type of program had been in place during Winter Storm Uri the impacts would have been minimal. With the right pricing signals (utilities) could incentivize voluntary load reductions thereby avoiding MANDATORY rolling blackouts."

BEC's CEO, William Hetherington, concluded in the PUCT filing, "We have the technology to operate an intelligent grid down to the appliance level, but we need energy efficiency programs and individualized demand response programs that tie directly to market pricing to keep the loss of power voluntary. If these programs had been in place last February, I believe that Voluntary load reductions would have been adequate to keep the grid for rolling blackouts on a statewide basis."

3. Could you please describe how deploying more electric vehicles helps improve grid reliability and resilience to climate impacts? How can EVs serve as a resource to a modernized, resilient grid?

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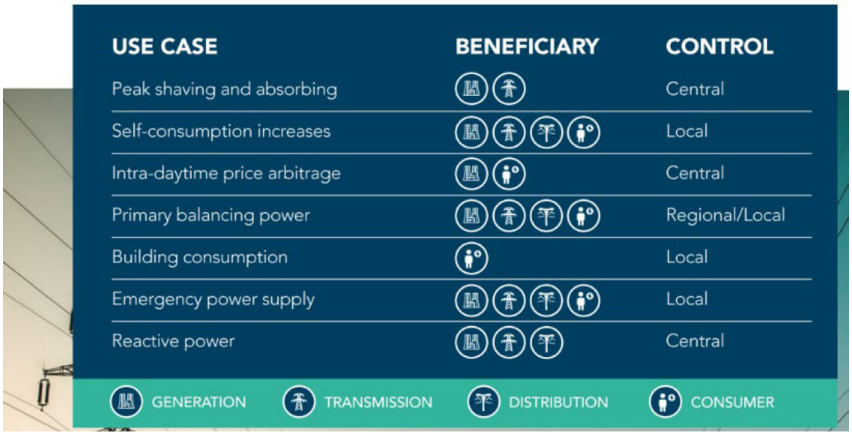
[2] U.S. Department of Energy. "Quadrennial Technology Review, Chapter 5: Increasing Efficiency of Building Systems and Technologies."
https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf, accessed March 22, 2021.

[3] https://www.ideasmiths.net/wp-content/uploads/2022/02/BEC_TX_FREEZE_HOMES_APW_20220212_v2.pdf

The GridWise Alliance recently published a report entitled, "Near-Term Grid Investments for Integrating Electric Vehicle Charging Infrastructure."[4] The report describes grid services that electric vehicles can provide when fully integrated, from peak shaving to balancing to emergency power supply (See Table 1.)

Table 1. Grid use cases supported by transportation electrification (Source: Dell Technologies)



Our report notes that "To enable these additional benefits, investments in hardening, upgrading, and modernizing the grid will be needed to ensure a safe, secure, reliable, and affordable electricity system. In this brief, we focus on investments that would be necessary to accommodate an initial exponential EV share increase. While we expect these near-term investments to include those that support managed charging and time-of-use pricing programs, they may not yet enable EVs to support aggregated grid services. It is important that any near-term grid-side investments are "no-regrets" investments that allow for and support the increasing integration of EVs."

4. How do your members think about public-private partnerships in the context of upgrading the electric grid?

Our members support public-private partnerships in the context of upgrading the electric grid. For example, the GridWise Alliance recommendations for grid investments in Bipartisan Infrastructure Law included cost-share programs for improving grid resilience and flexibility where private dollars would be leveraged by federal funding.

5. In your testimony, you mentioned the successes of the Section 48C Manufacturing Tax Credit when it was included in the 2009 Recovery Act. How would a tax credit for domestic manufacturing of grid technologies help your members?

Section 48C Advanced Manufacturing Tax Credit in the 2009 American Recovery and Reinvestment Act (ARRA) originally provided a 30 percent investment tax credit to 183 domestic clean energy manufacturing facilities valued at $2.3 billion and was extended to provide an additional $150 million in 2013. The tax credit helped build a U.S. manufacturing capacity and supported significant growth in U.S. exports. Almost three times as many companies submitted applications for the 48C tax credit as were approved by DOE, demonstrating significant interest by the clean energy industry in investing in domestic manufacturing. Qualifying manufactured clean energy products in the statute include electric grid equipment to support the transmission and distribution of electricity, which would include technologies manufactured, sold, purchased and deployed by GridWise Alliance members.

6. High-voltage direct current transmission lines could help connect transmission interconnections and transmission regions, which would

[4] https://gridwise.org/wp-content/uploads/2022/02/GWA_22_NearTermGridInvestmentsEVChargingInfra_Final.pdf

allow more Americans to access clean energy. What Federal investments could ensure that these HDVC transmission lines are themselves resilient to the unavoidable impacts of climate change?

The Bipartisan Infrastructure Law includes two programs that will catalyze investments in grid resilience:

- **Preventing Outages And Enhancing The Resilience Of The Electric Grid.** This funding will be administered by the new Grid Infrastructure office created during DOE's recent reorganization. IIJA divides the $5 billion funding into two grant programs—one at DOE and the other to states and tribes—to support utility resilience investments. The DOE grants will carve out 30% for small utilities (annual sales less than 4 million MWh), and the state carve out will be based on a percentage of customers served by small utilities.
- **Electric Grid Reliability and Resilience Research, Development, and Demonstration.** This $6 billion program, which will be administered by DOE's new Clean Energy Demonstration Office, will provide grants to demonstrate innovative approaches to enhancing resilience across the transmission and distribution systems. Congress included a carve out for rural and remote areas of $1 billion.

Both programs could support improving the resilience of existing HVDC transmission lines. However, given the limited mileage of HVDC transmission in the United States, resilience demonstration funding is the more likely funding stream for exploring how to make HVDC lines more resilient to climate change.

7. Why is it important for the federal government to invest in recycling and reuse of critical minerals that are important inputs to batteries and other clean energy technologies? For instance, the Bipartisan Infrastructure Law invests $7 billion in critical mineral supply chains, including a $140 million program recently announced by the Department of Energy to develop a first-of-a-kind refinery to extract rare earth elements from coal ash waste. How could these efforts complement new mining and processing domestically and around the world?

The GridWise Alliance recently responded to a Department of Energy Request for Information (RFI) on supply chain issues.[5] In our submission, we note the importance of recycling critical minerals used in batteries and other grid technologies:

"Whether directly connecting to the grid as a resource, being paired with home solar panels to support system operation, or connecting to the grid as the engine in a electric vehicle, the quantity of energy storage on the electric grid is increasing year over year. Lithium-ion (li-ion) batteries are a dominant energy storage technology today. A primary vulnerability of this technology is battery cell manufacturing and a strategic opportunity could lie in second battery life manufacturing (recycling) in the U.S. In short order, thousands of li-ion batteries from both electric vehicles and other industries will be reaching their end of life. Investment in the research of technology and production methods is needed to understand optimal ways to reuse the materials in batteries with minimal pollution. Beyond li-ion batteries, there are a variety of other energy storage technologies both in use and under development. Other energy storage technologies include:

- other batteries (using different electrochemical technologies),
- hydrogen and its various transport/storage mediums (such as ammonia),
- thermal,
- compressed air, and
- pumped hydro.

For most of these technologies, the greatest supply chain vulnerability lies in the mining and refining of rare earth elements and critical minerals."

THE HONORABLE VERONICA ESCOBAR

1. Can you please talk a little more on how investing in an aging transmission system can benefit states like Texas, and why it is important

[5] https://gridwise.org/wp-content/uploads/2022/01/GridWiseAlliance_EnergySectorSupplyChain_DOERFI.pdf

that local governments take advantage of federal funding that would advance grid resiliency.

GridWise Alliance member Bandera Electric Cooperative notes that as a transmission owner in Texas, the ERCOT model has numerous benefits, but it also has flaws. One of the flaws is the process of how transmission projects are reviewed and prioritized in Texas. By investing in more transmission you are improving the grid capacity. One of the contributing factors to inadequate supply during Winter Storm Uri was the capacity constraints on the transmission grid. Most of the resources are in west Texas and most of the load is in east Texas and therefore a robust transmission grid is vital to avoiding future power interruptions due to extreme events.

Questions for the Record

Mark Mills
Senior Fellow
Manhattan Institute

THE HONORABLE GARRET GRAVES

1. **You have stated in "Consider the implications just for California. If the rest of the nation switches to a solar/wind grid, California won't be able to count on neighboring power plants to make up for losses during regional dips in wind and sunlight availability."[1]**
   - **Can you explain what you mean and why this is important?**

California imports roughly 30% of its electricity from adjoining states. If there are wind/solar 'droughts' across the region, CA residents can (and have) counted on those (non-wind/solar) imports from conventional power plants in the neighboring states to keep the lights on. When, or if, all the neighboring states also have wind/solar as primary sources of electricity, the lights wil go out when there is a large regional wind/solar 'drought'—as happened in northern Europe this past fall, and as it did over the entire mid-West of the US for 10 days in July 2021, and as meteorological records show, happens frequently over entire continental areas.

2. **You have spoken about the scale and magnitude of the materials we need for a "green" power system.**
   - **Can you speak to our existing regulatory regime and the United States' ability to meet this increasing demand for critical minerals?**

The challenges with, and opposition to, opening new mines and mineral processing in America has been well documented by federal, state and private entities and frequently addressed by Congress over the decades. In general, new mines take more than two decades from concept to opening; if they can be opened at all. The current Administration, for example, recently cancelled new mines in both Minnesota and Alaska, even in the face of escalating mineral demands and imports, and prices.

3. **In order to have a true impact on global emissions, we need to work toward technology that is affordable and exportable. Developing nations need sources of inexpensive, secure, and reliable sources of energy to develop their economies—especially as global energy demand is expected to increase nearly 50% by 2050.**
   - **What technologies do you see that the U.S. has an advantage and can become exportable in the next 5–10 years?**

On the fuel supply side of the equation, the U.S. is the world's biggest natural gas and oil producer and could expand its "clean" capabilities to produce and export more of both. On the energy consumption side, many U.S. firms and entrepreneurs have developed radical improvements in combustion engine efficiency; facilitating and exporting such technologies would be a faster and lower cost means to reducing global fuel use and thus emissions.

   - **What challenges exist to the deployment of these technologies—within and outside of the United States?**

[1] https://www.city-journal.org/california-switch-to-primarily-solar-and-wind-powered-grid-is-dead-end

It is perhaps obvious that there is not a favorable political and policy environment to support, in any fashion, the development of technologies that lead to more efficient production and use of hydrocarbons.

4. Do you think President Biden's Paris Climate Commitment to reduce GHG emissions by 50% by 2030 is achievable?

No. It is both structurally—in engineering and science terms—and economically unachievable. The only path to such a radical reduction in emissions would be through a collapse in economic growth and prosperity.

Questions for the Record

Katherine Hamilton
Chair, 38 North Solutions
Chair, Global Future Council on Clean Electrification
World Economic Forum

THE HONORABLE KATHY CASTOR

1. The United States is blessed with affordable and abundant renewable energy resources, but they are often located far away from densely populated cities. Upgrading and expanding our electric grid could help ensure that every American can access clean energy. The Biden Administration has already launched an initiative to use existing rights-of-way to site transmission to make this easier.

a. How would upgrading and expanding the electric grid improve electric grid reliability and resilience as we transition to a clean energy economy?

Building high capacity, high voltage, and long-distance transmission lines underground along existing transportation corridors to connect abundant and affordable renewable energy to demand centers will improve both electric grid reliability and resilience. Such transmission facilities will enable wind and solar development where it is most abundant and cost-effective and from areas otherwise constrained by lack of access to transmission. These interstate and often interregional transmission facilities will help avoid blackouts and allow renewable energy resource-sharing among regions. For example, underground transmission cable installation along railroad rights-of-way provides a climate resilient lifeline between states, regions, and energy markets to stabilizes the grid, ensuring weather-related events have minimal impacts. Taking advantage of opportunities to develop high-capacity underground transmission will help ensure power reliability as the clean energy transition accelerates. The Biden Administration announced the Building a Better Grid initiative that will be solving for multiple challenges at once. From an infrastructure standpoint, the U.S. needs to expand transmission by 60% by 2030 and perhaps triple it by 2050.[1] Funding in the Bipartisan Infrastructure Bill will enable transmission build-out that in turn is foundational for achieving the Administration's goal of 100% clean electricity by 2035. Grid Strategies' analysis of Winter Storm Uri's impact on Texas one year after Winter Storm Uri makes the case for resilience through better transmission planning and investment.[2] As an example of a state taking decisive action to tie transmission build-out to resilience, the California Independent System Operator recently approved 23 transmission projects totaling nearly $3B that are expected to increase resilience in the state.[3]

b. How would upgrading and expanding the electric grid help consumers save money on electric bills?

Expanding the power grid will unlock otherwise inaccessible high quality and low-cost renewable energy resources that can benefit consumers. Providing much needed export paths to market for such resources will directly help consumers save money on electric bills. Access to such affordable resources will be increasingly important as more aspects of our economy are electrified, including homes and transportation. It is estimated that for every $1 spent on transmission, $3 of savings are achieved

[1] https://www.environmentalleader.com/2022/01/doe-launches-initiative-to-upgrade-nations-electric-grid/
[2] https://gridprogress.files.wordpress.com/2022/02/the-one-year-anniversary-of-winter-storm-uri-lessons-learned-and-the-continued-need-for-large-scale-transmission.pdf
[3] https://www.pv-tech.org/caiso-approves-us2-9bn-of-transmission-projects-to-enhance-reliability/

by consumers.[4] PJM, the largest energy market in the world, runs over 84,000 miles of transmission and estimates that transmission lines that link PJM zones together allow them to share capacity and leverage load diversity, reducing the need for additional generation by up to $3.78 billion annually. New transmission projects in the works could save $100 million in the first four years of commercial operations.[5] In late 2020, Local Solar for All, the Coalition for Community Solar Access, Vote Solar, and Vibrant Clean Energy released a road map for the lowest cost grid. Their modeling shows that local distributed solar plus storage could save customers $473B by 2050, while unlocking the full potential of utility scale wind and solar.[6] Stepping back to look at the entire U.S. electricity sector, if it were to be fueled entirely by clean energy, consumers would avoid using 437 million tons of coal,[7] 11.6 trillion cubic feet of natural gas,[8] 72 million gallons of oil,[9] and avoid approximately $107 billion in costs used to purchase these fuels (at 2021 prices) each year. Transitioning to a cleaner grid should save consumers on their electricity bills.

2. How would the Bipartisan Infrastructure Law and the initiative to use existing rights-of-way facilitate transmission development without compromising environmental protections?

Pernicious siting and permitting issues often impede the deployment of overhead interregional transmission lines. Such projects typically take ten or more years to develop, assuming they can be built at all given landowner opposition, environmental impacts, among other barriers. In contrast, installing high voltage transmission lines safely underground along existing railroad rights-of-way manages the typical impediments to long distance transmission development. By protecting landowners, avoiding eminent domain, and eliminating visual impacts, underground installation along existing transportation corridors simplifies and expedites permitting, allowing the project to be built in half the time of traditional overhead transmission projects while avoiding nearly all environmental impacts associated with major linear infrastructure development. This underground rail co-location development approach can use horizontal directional drilling to avoid any sensitive habitats, ecosystems, or waterways, further ensuring environmental protections. There are several programs within the BIL that provide support for using existing transmission rights of way. One project example is that of SOO Green HVDC (High Voltage Direct Current) Link, which would follow existing rail and highways rights of way to bury HVDC lines connecting wind resources in Iowa to load centers in Chicago. Because the rights of way were already developed by rail and roadways, burying cable along the same path would have minimal environmental impact.[10] Another example would be using overhead transmission technologies, such as high-ampacity low sag lines and HVDC, as well as MVDC (Medium Voltage Direct Current), that can move more power than conventional Alternating Current transmission lines within existing rights of way with less or no additional impact on the environment. Other new technologies include superconductors that could move five-times the amount of power over long-distances in the same space as conventional overhead transmission with shorter towers, a narrower right of way, and far less environmental impact.[11] Research funds in the BIF would help accelerate the development of this technology with significant benefit to the electric grid, while reducing impact on the environment.

3. Energy efficiency is a critically important near-term strategy because it can help Americans save money on their household energy bills and on their transportation fuels as well as reduce carbon pollution. In your testimony, you also highlighted the energy efficiency investments from the Bipartisan Infrastructure Law and referenced the Solar Energy and Loan Fund from my home state of Florida. Could you please help us understand how energy efficiency *also* helps improve grid reli-

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[4] https://gridprogress.files.wordpress.com/2022/02/the-one-year-anniversary-of-winter-storm-uri-lessons-learned-and-the-continued-need-for-large-scale-transmission.pdf

[5] https://pjm.com/-/media/library/reports-notices/special-reports/2019/the-benefits-of-the-pjm-transmission-system.ashx?la=en

[6] https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/LocalSolarRoadmap_FINAL.pdf

[7] https://www.eia.gov/energyexplained/coal/use-of-coal.php

[8] https://www.eia.gov/tools/faqs/faq.php?id=50&t=8#:~:text=In%202020%2C%20the%20United%20States,(Tcf)%20of%20natural%20gas

[9] https://www.eia.gov/tools/faqs/faq.php?id=33&t=6#:~:text=EIA%20uses%20product%20supplied%20to,day%20over%20consumption%20in%202020

[10] https://www.soogreenrr.com

[11] See technology being developed by VEIR: https://veir.com

ability and resilience to power interruptions and other disruptive events?

The Department of Energy's Better Buildings program has developed case studies and other resources for communities and consumers who want to deploy energy efficiency technologies to increase resilience. Energy efficiency alone can allow for passive survivability during a disaster, while also providing reduced disruption from demand spikes, lower costs for energy, greater comfort, and healthier air quality during normal grid operations. By including onsite generation like solar power and storage, customers can continue electric service during a disruptive event.[12] Many providers of renewable energy resources first install energy efficiency measures to maximize the savings from the solar resource. For example, before installing rooftop solar, PosiGen, a Louisiana-based rooftop solar company that focuses on low-income communities, conducts an energy audit and installs energy efficiency measures to ensure bill savings from the solar system are achieved and protected.[13]

4. In your testimony, you highlighted that the EV charging investments in the Bipartisan Infrastructure Law are important for grid resilience. You also cited a study from the American Council for an Energy-Efficient Economy which concluded that increased electrification of vehicles and buildings paired with energy efficiency would *increase* grid reliability. Could you please describe how deploying more EVs and distributed energy resources (DERs) helps improve grid reliability? How can EVs and DERs serve as resources to a modernized grid?

A recent study by the Pacific Northwest National Laboratory looked at how a distribution system operator (DSO) along with active customer engagement (Transactive Energy) could coordinate a variety of flexible assets such as electric vehicles (EVs) and distributed energy resources (DERs) to reduce load, lower energy prices, and lessen needed infrastructure.[14] The grid is constantly working to maintain balance between supply and demand; an overbalance of either or disruption to delivery lines can cause the entire system to falter. DERs, when properly incentivized and constructed, improve grid reliability by giving more options for grid operators to manage that supply and demand. In PJM alone, DERs account for between 15–25% of demand response. EVs have the promise of similarly serving as flexible demand. A future grid would ideally be able to take advantage of these mobile services by allowing EV-to-Grid operations where EVs can charge or discharge where needed to support the grid. California is experimenting now with using EVs to power homes as electricity demand and renewable energy both increase.[15]

5. In your testimony, you noted that additional climate investments like the clean energy and energy storage tax credits and the Greenhouse Gas Reduction Fund will help encourage more private sector investment in climate solutions. Could you please help us understand how Federal investments can unlock private sector capital, which is a much bigger market? What are some examples of public private partnerships?

The goal of the federal government should be to send market signals that organize the nation around clear goals—in this case the goal of reducing our nation's impact on the climate—and to fill gaps that the private sector is unable to fill. In the case of the Greenhouse Gas Reduction Fund, we know that last year state green banks drove nearly $2B in investment and in total have caused $9B in total investment, leveraging private capital three to one. While 42 states, the District of Columbia, and Puerto Rico all have active or nascent green banks, a national entity would capitalize and supercharge this state activity. Many of these state programs do not have enough state funding to leverage with that of the private sector; this national fund would ensure those state entities are able to run their own entities while also financing projects of broad national importance.

Another way in which policy can unlock private sector capital is through tax credits with direct pay provisions. The current regime forces project developers to work through financial middlemen in a supply constrained tax equity market to monetize the tax credit for renewable energy. The legal cost of this is prohibitive for many distributed energy projects which have a capital expenditure of under $1 million and

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[12] https://betterbuildingssolutioncenter.energy.gov/resilience/about

[13] https://www.posigen.com

[14] https://www.pnnl.gov/sites/default/files/media/file/EED_1574_BROCH_DSOT-ExecSumm_v11.pdf

[15] https://www.morningbrew.com/emerging-tech/stories/2022/03/18/california-s-vehicle-to-grid-experiments-offer-a-glimpse-of-the-future

is even more difficult for residential projects, especially for those customers who do not have a tax burden at all and would not be able to take advantage of an investment tax credit. As Jon Powers, President of CleanCapital states in a recent article in PV magazine, "to say this creates a major bottleneck in clean energy investment and deployment is an understatement. At a time when the opportunity for the energy transition is greatest, two thirds of wind projects set to being construction this year are still seeking tax equity financing, along with more than half of large-scale solar projects. These delays hold America back from its potential as a global clean energy leader."[16] Smaller projects face an even more difficult path to monetization. And yet, despite these numbers, solar has grown 52% annually since enactment of the ITC in 2006.[17] While solar and other renewables would expand exponentially with a more efficient direct pay option, even this constrained ITC has already made a significant impact in encouraging private sector investments in climate solutions. This construct also creates opportunity for not-taxed entities like municipalities and tribes to better extract value from the incentive.

6. How would American companies benefit from the Section 48C incentive to manufacture climate solutions in this country?

According to the National Association of Manufacturers, manufacturing jobs have one of the highest multiplier effects of any industry[18] Modeling done by Data for Progress concluded that federal investments of $8 billion through 48C would create nearly 140,000 direct and indirect jobs nationwide over the next several years, and would add over $27 billion to our Gross Domestic Product (GDP).[19] The think tank Third Way, in collaboration with Industrial Economics, Inc., found in their modeling that for every $1 billion issued annually through a new 48C credit program, $3.6 billion in GDP would be added and roughly 8,000 direct jobs created across the country, a number that would reach 23,000 annually with indirect supply chain and "induced jobs."[20] Not only manufacturers would benefit—the entire ecosystem will. For example, underground HVDC transmission cable is not currently manufactured in the U.S. Creating incentives for cable manufacturing will thus impact the speed and cost of transmission development. Another example is in hydropower, a zero-emission resource. Small turbines—between 5-30 megawatts—are not manufactured in the U.S. Based on the U.S. DOE Hydropower Vision, 13GW zero emission hydropower could be added to the clean energy mix by simply upgrading existing plants and adding power at existing dams.[21]

7. High-voltage direct current transmission lines could help connect transmission interconnections and transmission regions, which would allow more Americans to access clean energy. What Federal investments could ensure that these HDVC transmission lines are themselves resilient to the unavoidable impacts of climate change?

Direct current lines do not have same sensitivity to higher ambient temperatures as AC lines since they do not generate heat within the line, so in the case of extreme temperatures, DC lines will perform better.

Investments should also be made in sensor-based Dynamic Line Rating (DLR) technology that provide transmission owners and grid operators with improved situational awareness and real-time visibility, increasing the resilience of the system overall. Real-time sensors equip grid operators with data on the performance of their transmission lines, helping to optimize safety and reliability of the transmission grid. Conductor asset health reports provide valuable information used for prioritizing maintenance activities and efficiently dedicating resources. DLRs can also unlock greater grid flexibility, enabling operators to accommodate shifting loads and reduce interconnection queues while also improving reliability in N-1 scenarios.

8. Why is it important for the federal government to invest in recycling and reuse of critical minerals that are important inputs to batteries and other clean energy technologies? For instance, the Bipartisan Infrastructure Law invests $7 billion in critical mineral supply chains, including a $140 million program recently announced by the Department of Energy to develop a first-of-a-kind refinery to extract rare

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[16] https://pv-magazine-usa.com/2022/02/28/clean-energy-tax-credit-reform-is-our-last-best-chance-for-a-net-zero-future/

[17] https://www.seia.org/sites/default/files/2021-01/SEIA-ITC-Factsheet-2021-Jan.pdf

[18] https://www.nam.org/facts-about-manufacturing/

[19] https://www.dataforprogress.org/memos/the-cepp-amplifies-the-jobs-impacts-of-the-48c-tax-credit

[20] https://www.thirdway.org/memo/manufacturing-the-future-of-clean-energy-with-48c

[21] https://www.energy.gov/sites/default/files/2018/02/f49/Hydropower-Vision-021518.pdf

earth elements from coal ash waste. How could these efforts complement new mining and processing domestically and around the world?

Many of the materials essential for Lithium-Ion Batteries (LIBs) are not found in the U.S., making it vital that the U.S. invests in minerals processing and a supportive trade policy with nations that have these natural resources. Nickel, for example, is an essential element for today's batteries. Most of the nickel used for the LIB industry today comes from mature Western and Japanese nickel companies making nickel powder, briquette and nickel sulphate. There is currently no nickel mining and/or processing of nickel salts for the battery industry in the U.S. and today's nickel price does not support investment in new mines and processing facilities. Given that Indonesia and Philippines are the key countries for nickel deposits, U.S. refiners will most likely have to rely on growth of new feed coming from these countries in the coming years, with smaller amounts from new mines in Australia, New Caledonia, and Brazil.

Lithium is of course another essential element for LIBs. Most lithium comes from brine resources in South America and rock resources in Australia. The U.S. currently has one active lithium mine, Albemarle's Silverpeak, a small brine-based lithium carbonate production in Nevada. Additionally, North Carolina hosts two conversion assets from carbonate to hydroxide from both Livent and Albemarle in addition to a halted spodumene mine at Kings Mountain. The U.S. also has a diverse lithium junior company community that is exploring geothermal and clay to more conventional lithium resources like brine and spodumene.

Cobalt is still an important element used in the cathode for most LIBs, especially those used for electric vehicles. The U.S. does not have any significant domestic sources of cobalt, nor does it have cobalt refiners. Cobalt is not mined on its own but is rather most commonly a by-product from copper or nickel mining. Over 60% of the global cobalt supply originates from the Democratic Republic of Congo.

Furthermore, cobalt refining is predominantly a China-based business. One company—Umicore—is an exception to the Chinese cobalt refining dominance, operating the only significant non-Chinese cobalt refining operations in Kokkola, Finland and Olen, Belgium that is used to supply western nations.[22]

For the U.S. to meet its needs for these metals and an advanced energy economy, we should focus on working with trusted allies to increase its access to supply. Additionally, the U.S. can invest in the low-cost, low-emission technologies needed to process battery raw materials, ideally using resources found in the U.S. to convert them into a form used in LIBs. This could help support the development of a market for the precursor materials which require these raw materials and are in turn used to produce cathodes for LIBs.

To further mitigate risk for the U.S. market, the Department of Energy and other U.S. policymakers could create a policy framework that incentivizes domestic manufacturers along the battery supply chain. Refining materials and manufacturing cells within U.S. borders would mitigate a great deal of supply chain risk for this growing domestic industry. The North American LIB supply chain could be incentivized through a revised regional approach. Currently, there are no incentives to locally produce components (i.e., cathode active materials) used in LIB production. A regional agreement in North America could motivate important regional supply production investment, mitigating domestic national security risk, while promoting increased collaboration with allies such as Canada which has important raw material resources.

Taking steps that result in the growth of a robust U.S. electric vehicle market will help to reduce investment risk and uncertainty for LIB supply chain participants who are considering establishing manufacturing in the U.S. In addition, this market certainty would foster an environment in which critical materials recyclers, such as Umicore which operates a battery recycling plant in Belgium,[23] would want to site their plants here in the U.S. closer to the EV and battery manufacturing ecosystem.

9. How can we help industries with expertise in legacy fossil fuel technologies become partners in the transition to a clean energy economy?

While it might seem counterintuitive, it is critical to engage oil, gas, and fossil fuel companies in energy transition efforts if we want to make our 2050 climate goals. Given that the next 10-20 years will be crucial in preventing the worst im-

[22] https://csm.umicore.com

[23] https://www.umicore.com/en/newsroom/news/new-generation-li-ion-battery-recycling-technologies-and-announces-award-with-acc/

pacts of climate change, we must work with the fossil fuel industry to reduce their emissions as they continue to be a sizable part of our energy mix.

As an example of the incumbent fossil fuel industry stepping up to scale a low carbon future, Greentown Labs in Houston, TX, has been collaborating with oil and gas companies since their founding. Shell and Chevron were some of the Lab's earliest partners and both helped Greentown expand nationally. These corporate partners understand and can provide the scale needed to deploy energy transition solutions; existing fossil fuel companies have the capital, talent, and operational capacity to bring new technologies to scale within the looming climate timeframe. Hydrogen and CCUS/carbontech are two of the most promising solutions to decarbonize power generation as well as two of the fastest growing sectors of climate tech. Greentown Labs is currently running two programs in partnership with industry partners: the Low Carbon Hydrogen Accelerator[24] and the Carbon to Value Initiative.[25] With both initiatives, corporate partners like Shell, NRG, Fluor, and ConEdison leverages company expertise and incubation services to drive an innovation ecosystem for commercializing climate mitigating technologies.

10. What types of Federal investments would increase equity and access to clean energy while also enhancing grid resilience and reliability?

To ensure programs and federal investments are equitable and allow access by all Americans, we must be intentional in our policy development. We cannot assume that by using the word "equity" that it will then happen. A coalition of private sector companies, environmental and civil rights groups collaborated to develop a roadmap that would ensure equity is included through federal climate policy.[26] These policies include direct pay provisions in the tax code, bonus credits for low and middle income communities, and, crucially, funding for state, local, and tribal governments to fund existing and new distributed and community solar programs to ensure that at least 50% of incentives support underserved communities, communities of color, indigenous communities, rural, and low to moderate income households. All of these policies not only expand access to clean energy, but also increase resilience inherent in those technologies.

11. While the Investment Tax Credit has been helpful in driving down the costs of solar energy, there are still additional barriers to deployment at the scale required by the climate crisis. Could you please describe the scale of solar deployment we need and describe some of the remaining barriers? How could extension of the Investment Tax Credit help? What other Federal policies would be helpful?

The Investment Tax Credit was momentous for the solar industry, and yet more is needed to address, for example, consumers who rent their homes or who live in multi-family housing, communities that are in low- and middle-income areas, and those who live in areas historically adversely impacted by extractive or polluting industries. Direct pay, bonus credits, and interconnection tax credits as well as complementary credits for energy storage, microgrids, and transmission will all create the market signals for an ecosystem of U.S. investment in clean energy. For solar specifically, the Solar Energy Industries Association has set a goal of 100 GW (30%) by 2030;[27] the Coalition for Community Solar Access has set a goal of 20 GW by 2025 for community solar.[28] These goals align with the Biden Administration and indicate a commitment by industry to deploy apace once policy certainty is in place.

12. In your view, could you please describe the types of Federal policies that would enable the country to meet President Biden's goal of reducing economy-wide emissions by 50% by 2030?

Federal policy will be an important part of achieving 50% emissions reduction by 2030. Policies that can enable that goal include a combination of tax incentives, grant programs, rebates, appliance standards, building codes, emissions regulation, and consistent research and development to foster and seed ideas for the future energy transition. The Select Committee on the Climate Crisis released a report and

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[24] https://greentownlabs.com/lcha/

[25] https://www.c2vinitiative.com

[26] https://static1.squarespace.com/static/5f4637895cfc8d77860d0dbc/t/607de3e8885bd43ae87deded/1618863082445/Building+Back+Better_+A+Roadmap+to+Expand+Solar+Access+for+All+-+FINAL.pdf

[27] https://www.seia.org/research-resources/solar-decade-american-renewable-energy-manufacturing

[28] https://www.communitysolaraccess.org/community-solar-industry-commits-to-develop-20-gw-of-capacity-by-2025-in-alignment-with-u-s-department-of-energy-goals/

action plan with many of those policy recommendations [29] and the Build Back Better Act [30] in concert with the Bipartisan Infrastructure Law will send the appropriate market signals to the private sector that clean energy transition investments will create jobs, reduce risk from climate change, lower costs, and increase resilience.

13. From your work on global decarbonization, could you please describe the kinds of technologies that are most beneficial to developing countries to help them meet their climate and economic development goals? How would renewable energy and electric vehicles help developing countries leapfrog over legacy fossil fuel technologies?

Many people in mature markets have an impression that developing economies simply need a solar panel to serve a light bulb and perhaps a sewing machine or a refrigerator. To be clear, those technologies can be life changing for girls and women to study and gain economic independence.[31] Emerging economies, however, need more than just solar panels, and most of the issues facing these economies are not technology related. According to Blackrock, emerging economies will need $1T in investment for the zero emission transition, not because of technology issues but because of political, legal, regulatory, and macroeconomic risk.[32] Another report from IEA and the World Economic Forum discusses financing opportunities in emerging markets for energy efficiency, electrification, clean power, and emissions-intensive sectors.[33] The issue in all of these analyses is not about technology solutions but about financing and policy structures that can reduce risk and accelerate deployment.

THE HONORABLE GARRET GRAVES

1. In your testimony you state that transmission ties could have helped bring power from states like Alabama and Louisiana to Texas in the aftermath of Winter Storm Uri to ultimately reduce recovery time. You blamed a lack of investment in transmission as why this didn't happen. In our hearing, you stated that "there are plenty of ways to get transmission built." I agree that we need to make smart investments to deploy innovative technologies, but all the money in the world won't overcome the other barriers to deployment of these technologies, particularly for projects that cross state lines.

a. How many federal agencies are involved in the permitting process for projects like this, and how many permits would these projects need?

The number of agencies involved in permitting will vary based on the technology and application. Energy projects are not materially different from developing any infrastructure policy in the approvals needed to proceed.

b. Do you think the currently regulatory barriers that are in place—that often delay projects like the ones you reference by 7–10 years—should be reformed to allow for faster deployment?

Based on my experience, the regulatory barriers that exist today are often caused by a lack of adjustment in regulation to include new technologies with new characteristics that were not contemplated at the time of the original regulation. It is helpful when federal agencies set up processes or platforms to help developers track progress and approvals for projects.

c. Your testimony references "market signals"—would one of those signals be a permitting process that provides certainty to developers and utilities alike to attract investment and actually get things built?

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[29] https://climatecrisis.house.gov/report

[30] https://climatecrisis.house.gov/sites/climatecrisis.house.gov/files/Climate%20Investments%20In%20The%20Build%20Back%20Better%20Act%20Fact%20Sheet%2011-19.pdf

[31] Companies like Solar Sister have made an enormous difference in the lives of women in Sub-Saharan Africa:
https://www.un.org/en/chronicle/article/sustainable-energy-all-empowering-women

[32] https://www.reuters.com/business/sustainable-business/emerging-markets-need-1-trln-year-get-net-zero-blackrock-2021-10-14/

[33] https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies?utm_content=buffer7259e&utm_medium=social&utm_source=twitter-ieabirol&utm_campaign=buffer

Certainty is crucial for investment. In fact, many investors are sitting on the sidelines today awaiting passage of the reconciliation package for exactly that reason. Developers and utilities must plan several years ahead, so understanding how the policy landscape will look over the next decade is of utmost importance. I am party to several Integrated Resource Planning proceedings throughout multiple states, including Louisiana, and know it is very difficult for utilities to model and plan long term without an understanding of policies that will be in place that can impact their supply and demand side resources.

2. The Princeton University study that I cited in our hearing found that in order to meet net zero by 2050, "high voltage transmission capacity expands ~60% by 2030 and triples by 2050. . . total capital invested in transmission is $330 billion through 2030 and $2.2 trillion by 2050."[34]

a. Do you think this massive expansion of capacity and the needed capital investment will increase costs for utilities and therefore increase rates for consumers?

While there is a need to expand transmission investments, that investment does not necessarily translate into higher costs for consumers. Based on the report by Grid Strategies that I cited in my testimony, for each gigawatt of transmission capacity, more than $100 million of consumer savings can be generated during an extreme weather event. An Investment Tax Credit for transmission could spur $37B in new transmission deployment, resulting in $75B in customer savings.[35] In addition, there are low-cost solutions with Grid Enhancing Technologies (GETs) like Dynamic Line Ratings that can maximize capacity for renewables integration. A recent study by The Brattle Group found that GETs can double the amount of renewable energy integrated onto the grid, and deliver $5B in consumer cost savings nationally, with a payback of under six months.[36] Importantly, these technologies can be deployed in weeks or months, and at a unit cost of less than 5% of traditional projects. To minimize the potential cost impacts of future infrastructure development, technology solutions that can enable additional capacity with existing infrastructure at a fraction of the cost of traditional transmission line construction projects and without requiring a time-consuming permitting process could be prioritized.

b. Have you seen any strategic plans laying out how to specifically achieve the amount of expanded capacity that is needed to achieve these goals?

Many analysts have considered how to achieve a future of zero carbon emissions. One example is Energy Systems Integration Group that has focused on the grid and found that the cheapest solutions to the transition are coordinated transmission and distributed energy planning. Their modeling team found that "when clean electricity is not a target, the savings materialize immediately and reach to over $300 billion cumulatively by 2050. When clean electricity is mandated, the savings are less in the early years (through 2030), but expand rapidly to over $470 billion by 2050."[37] Barclay's released a five pillar approach to zero emissions that lays out the need for ending waste, increasing electrification, reinvigorating bioenergy, investing in hydrogen, and sequestering carbon.[38] There are no zero emission scenarios that promote the increase of the use of fossil fuels and even given the current situation in Ukraine, the International Energy Agency (which has proposed a scenario to move to net zero by 2050)[39] has proposed an acceleration of electrification and renewable energy deployment to reduce EU's reliance on Russian natural gas.[40] S&P Global found that climate change could have huge financial costs for corporations and almost 80 percent of the S&P Global 1200, which includes the world's largest compa-

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[34] Pg. 108: Princeton%20NZA%20FINAL%20REPORT%20(29Oct2021)%20(4)

[35] https://gridprogress.files.wordpress.com/2022/02/the-one-year-anniversary-of-winter-storm-uri-lessons-learned-and-the-continued-need-for-large-scale-transmission.pdf

[36] https://watt-transmission.org/unlocking-the-queue/

[37] https://www.esig.energy/coordinated-deployments-of-transmission-and-distribution-scale-resources-provide-the-lowest-cost-electricity/

[38] https://www.cib.barclays/our-insights/Emission-impossible-closing-in-on-net-zero.html?cid=paidsearch-textads_google_google_themes_decarbonization_us_research_net-zero_phrase_892853615478&gclid=‡CjwKCAjwiuuRBhBvEiwAFXKaNJVM7KvTLbEBW2zg-RLx1B8uDv6y6GHMINRBwZcyHJbKgVw-bzKYeBoCFfcQAvD_BwE&gclsrc=aw.ds

[39] https://www.iea.org/reports/world-energy-model/net-zero-emissions-by-2050-scenario-nze

[40] https://www.iea.org/reports/a-10-point-plan-to-reduce-the-european-unions-reliance-on-russian-natural-gas

nies, will be exposed to moderate-to-high physical risks from climate change by 2050.[41]

3. In your testimony you stated that "One of the most important market tools is in the tax code. Access to tax credits will drive down the cost of energy storage of all types, opening up new markets in dozens of States."

a. How long has the Investment Tax Credit (ITC) been in place for?

The Energy Policy Act of 2005 (P.L. 109–58) created a 30 percent ITC for residential and commercial solar energy systems that applied to projects placed in service between January 1, 2006, and December 31, 2007. The Solar Energy Industries Association has been tracking the credit and the growth it has spurred in the sector.[42]

b. What percentage of the nation's power is generated by solar energy?

Based on the Energy Information Administration and the Federal Energy Regulatory Commission, renewable energy resources provide 25.81% of total U.S. available installed generating capacity, more than coal, which generates 18.49% and three times more than nuclear power, at 8.29%.—a share significantly greater than that of coal (18.49%) and more than three times that of nuclear power (8.29%). More information is available in the References Page. Of the total renewable energy resources installed, solar energy, including utility scale and distributed solar, makes up 98.2 Gigawatts, or roughly 3%. Solar resources are projected to grow to 20% by 2050.[43] [44]

c. At what point do you believe we need to allow the free market to work and ensure that technologies can stand on their own two feet, rather than perpetually subsidizing a technology that hasn't been widely adopted in the market?

A 2021 International Monetary Fund report found that in 2021 fossil fuels—oil, natural gas and coal—were globally subsidized at $5.9 trillion, $660 billion of that in the U.S.[45] One could argue that those incentives are provided to proven technologies in long-profitable sectors. What is called the "free market" is a set of market signals—in part from states and the federal government—that encourage or discourage investment in certain sectors based on prioritization of attributes and characteristics of those resources. Because of the global and U.S. commitment to greenhouse gas reduction, it would follow that policy would send signals to the market to incentivize deployment of zero emission technologies.

Additional References (EIA and FERC)

"Energy Infrastructure Update for December 2021" was released by FERC on March 8, 2022.
https://cms.ferc.gov/media/energy-infrastructure-update-december-2021. See in particular the tables "New Generation In-Service (New Build and Expansion)," "Total Available Installed Generating Capacity," and "Generation Capacity Additions and Retirements."

"Energy Infrastructure Update for December 2020" report by FERC.
https://cms.ferc.gov/media/energy-infrastructure-update-december-2020

"Short-Term Energy Outlook" released by EIA on March 8, 2022 includes 2021 data for wind, utility-scale solar, and distributed solar.
https://www.eia.gov/outlooks/steo/report/electricity.php

"Electric Power Monthly" report by EIA released on February 25, 2022, "Total Electric Power Industry Summary Statistics, Year-to-Date 2021 and 2020."
https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=table_es1b

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[41] https://www.greenbiz.com/article/state-net-zero-now
[42] https://www.seia.org/initiatives/solar-investment-tax-credit-itc
[43] https://www.eia.gov/todayinenergy/detail.php?id=50357
[44] https://www.environmentalleader.com/2022/03/us-renewables-accounted-for-81-of-new-generating-capacity-in-2021-says-sun-day-campaign/
[45] https://www.imf.org/en/Publications/WP/Issues/2021/09/23/Still-Not-Getting-Energy-Prices-Right-A-Global-and-Country-Update-of-Fossil-Fuel-Subsidies-466004