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THE ELECTRIC GRID OF THE FUTURE

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

JUNE 7, 2018

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THE ELECTRIC GRID OF THE FUTURE

THURSDAY, JUNE 7, 2018

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 1:07 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Randy Weber [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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Subcommittee on Energy

The Electric Grid of the Future

Thursday, June 7, 2018
1:00 p.m.
2318 Rayburn House Office Building

Witnesses

The Honorable Bruce Walker, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, Department of Energy; Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response, Department of Energy

Dr. John Sarrao, Principal Associate Director, Science, Technology, and Engineering Directorate, Los Alamos National Laboratory

Mr. Robert Gramlich, President, Grid Strategies, LLC.

Dr. Joseph Heppert, Vice President for Research, Texas Tech University

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Thursday, June 7, 2018

TO: Members, Subcommittee on Energy

FROM: Majority Staff, Committee on Science, Space, and Technology

SUBJECT: Subcommittee hearing: "The Electric Grid of the Future"

The Subcommittee on Energy will hold a hearing *The Electric Grid of the Future* on Thursday, June 7, 2018, at 1:00 p.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of the hearing is to examine research programs and priorities within the Office of Electricity Delivery and Energy Reliability (OE). OE's research focuses on electrical grid modernization, the development of next-generation battery and grid-scale energy storage technologies, and improving grid reliability, grid resilience, and cybersecurity. The hearing will also explore cooperative research between industry, academia, and the Department of Energy (DOE) national laboratories, including through the DOE Grid Modernization Initiative and corresponding lab partnership titled the Grid Modernization Lab Consortium (GMLC).

Witness List

- **The Honorable Bruce J. Walker**, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, Department of Energy; Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response, Department of Energy
- **Dr. John Sarrao**, Principal Associate Director, Science, Technology, and Engineering Directorate, Los Alamos National Laboratory
- **Mr. Robert Gramlich**, President, Grid Strategies, LLC.
- **Dr. Joseph A. Heppert**, Vice President for Research, Texas Tech University

Staff Contact

For questions related to the hearing, please contact Jimmy Ward of the Majority Staff at 202-225-0222.

Chairman WEBER. The Subcommittee on Energy will come to order. Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time.

Welcome to today's hearing titled "The Electric Grid of the Future." I now recognize myself for five minutes for an opening statement.

And by the way, we may have votes called just in short order, so we're going to probably be a little quicker than normal here, not that anything we do here is very normal.

Today, we will hear from the Department of Energy (DOE), Los Alamos National Laboratory, the private sector, and Texas Tech University on research for creating the electric grid of the future. The goal of this research is to ensure energy delivery systems are reliable, resilient, and secure. A reliable grid delivers energy to consumers and businesses on demand regardless of the energy sources. A resilient grid keeps the energy flowing during an adverse event, such as a hurricane, and ensures a restoration of energy once an outage has occurred. A secure grid protects our energy infrastructure from hostile disruptions due to physical or cyberattacks, which are a growing risk as more industrial control systems are connected online.

The DOE Office of Electricity Delivery and Energy Reliability (OE) is leading the early-stage research and development programs that promise to deliver advancements in grid technology. Small but mighty, OE has the least amount of funding for applied energy programs at DOE but carries out a vital mission through partnerships with industry and research conducted by the national labs.

Los Alamos applies science expertise in physics, network science, algorithms, and applied mathematics to develop computational modeling and data analytics to help optimize modern electrical grids. Los Alamos developed these capabilities through its nuclear weapons mission. This kind of basic science expertise—with multidisciplinary applications—is part of what makes the national lab system an incubator for new technologies and continues to advance research beyond its originally intended goals.

Academia and industry are also partners on grid modernization research. Texas Tech University hosts the Global Laboratory for Energy Asset Management and Manufacturing, or GLEAMM, facility that works to develop innovative power technologies and advance next-generation energy delivery technology. GLEAMM focuses on wind, solar, battery storage, cybersecurity, and microgrid technologies that will all encompass the electrical grid of the future.

Advanced grid technologies can have a significant impact when the grid is faced with weather-related events that can threaten reliability. This month brings the official start of the 2018 hurricane season, and last year, communities in my home State of Texas, as well as Florida and Puerto Rico, lost power. Modern grid technology in Texas, such as the use of smart meters, were able to identify power outages and quickly help restore power after Hurricane Harvey.

Unfortunately, while they have made significant progress rebuilding capabilities, there are still communities in Puerto Rico without power. That's why DOE, OE, and five national labs led by

Argonne National Laboratory are working daily to provide grid modeling tools to Puerto Rico. The national labs are combining their current skills and capabilities in order to help Puerto Rico to plan, to operate, and to rebuild a more resilient grid. These models help grid operators better predict where the highest risk of power disruption could be and determine the potential impacts on critical power loads that support Puerto Rico's public health and its safety infrastructure.

The national labs hope by improving existing grid models the island will be able to make key investments in resilient energy infrastructure before the current hurricane season. Additional analysis will inform Puerto Rico on long-term investment priorities for electrical transmission, distribution, renewable energy, battery storage, microgrids, and strategic power reserves.

The partnership between the federal government, the national labs, academia, and industry has the potential to transform energy delivery systems. As we continue supporting advanced grid research, I would like to learn more about how DOE can improve the development of new technology and our understanding of electrical systems.

I want to thank our panel of witnesses for their testimony today, and I look forward to a positive discussion about grid modernization research.

[The prepared statement of Chairman Weber follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
June 7, 2018

Media Contacts: Thea McDonald, Bridget Dunn
(202) 225-6371

Statement by Chairman Randy Weber (R-Texas)

The Electric Grid of the Future

Chairman Weber: Today, we will hear from the Department of Energy (DOE), Los Alamos National Laboratory, the private sector and Texas Tech University on research for creating the electric grid of the future.

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I want to thank our panel of witnesses for their testimony today, and I look forward to a positive discussion about grid modernization research.

###

Chairman WEBER. I now recognize the Ranking Member of the Subcommittee, the gentleman from Texas, Mr. Veasey, for an opening statement.

Mr. VEASEY. Thank you, Mr. Chairman, and my fellow Texan, and everyone else that is here today, our distinguished panel.

Just last week, I want to remind everybody that a White House memo was leaked that raised several questions. It detailed a plan to direct the Energy Secretary, also from Texas, to use authorities vested in him from the Federal Power Act and the Defense Production Act to save coal and nuclear power plants. Section 202 of the Federal Power Act has historically been used to address energy supply concerns related to natural disasters, other major energy shortages. Likewise, the Defense Production Act is a Cold-War-era statute that allows the President to nationalize elements of U.S. industry in the interest of national security.

This proposal has been roundly criticized by a wide range of trusted independent experts, including Wall Street Journal editorial page, as poorly justified and legally dubious. Our utilities, States, and researchers do the hard work of hardening our energy infrastructure to cybersecurity threats and national disasters, and meanwhile, the Trump Administration is inventing emergencies to bail out coal and nuclear plants while ignoring the real problems.

I'm sure the White House views this legal loophole that surfaced in the leaked memo as an easy way to try to fulfill campaign promises, which is very bad and very unsound when it comes to energy policy. However, the real impact has not been thought through by the Administration.

It would wreak havoc on our energy markets and create a number of misaligned incentives. As severe weather, driven by climate change, becomes more intense and damaging to the electric grid, this Administration wants to address the problem by offering financial bailouts and picking winners and losers as it relates to coal, and any reasonable person would agree that this seems backward. Moreover, it wouldn't do anything to make the electric grid more resilient.

The grid experts that have examined the issue would characterize our nation's priorities far differently than this politically motivated Administration does. That is why FERC unanimously—they unanimously rejected Secretary Perry's last proposal to bail out coal and nuclear power plants. And while the Trump Administration works with coal CEOs to craft a plan to benefit the industry's bottom dollar, the American people are being left behind.

And I look forward to hearing today from Mr. Gramlich today on his recent report titled "A Customer-Focused Framework for Electric System Resilience." I can't think of a better way to approach this issue. The purpose of the electric grid is to provide reliable, affordable power to customers. Any conversation that does not first consider the customer is not worth having.

And while I am critical of these actions by Secretary Perry on grid resilience, I want to be clear that I strongly support developing advanced technologies to enable carbon capture on coal-fired power plants and the next generation of nuclear reactors. In fact, I just introduced a bipartisan bill, H.R. 5745, the Fossil Energy Research and Development Act of 2018, that would authorize activities to

support the development of technologies and methods for carbon capture, storage, utilization, and removal. It is the most comprehensive legislative proposal for fossil energy research in Congress today. So I certainly have no issues with federal support for these energy options. I just think that we need to be a lot smarter about how we approach these issues.

We're very fortunate to have Assistant Secretary Bruce Walker with us today. I look forward to hearing justifications for the actions proposed by Secretary Perry in the White House memo, as it was proposed to FERC. I also look forward to hearing your priorities for the Office of Electricity.

In the fiscal year 2019 budget proposal, the Administration requested a severe 37 percent cut to the Office of Electricity and reorganization of these investments. I'm sure we'll discuss that here shortly. And again, while I'm not opposed to the reorganization in concept, I'm curious how splitting DOE's smallest energy technology offices into two offices will ensure that these activities continue to be a priority in years to come.

And before I close, I also would like to take some personal privilege to note that, unfortunately, this will be the last time that Joe Flarida will be staffing us here on the Committee at least in this Congress. That's because he recently won the Bosch Foundation Fellowship and will be heading to Germany in a few weeks. I know that staff on both sides of the aisle recognize that Joe has done a tremendous job for the Subcommittee in his time here.

Sehr gut, Herr Flarida. Auf wiedersehen. And we look forward to seeing you when you come back.

He played a very key role in negotiating a bipartisan, bicameral legislative package, the Department of Energy Research and Innovation Act, that has since passed the House and is now advancing in the Senate. And he was the lead staffer in developing and vetting language for the fossil energy research bill that I previously mentioned. That bill has now been endorsed by a broad and impressive coalition of stakeholders, and I know that would not have happened without all the hard work that Joe put into this effort.

We wish you luck, and I hope that we can find a way to work together again. And I know you're going to have a great opportunity overseas. Congratulations, Joe.

And, Mr. Chairman, I yield back.

[The prepared statement of Mr. Veasey follows:]

OPENING STATEMENT
Ranking Member Marc Veasey (D-TX)
of the Subcommittee on Energy

House Committee on Science, Space, and Technology
Subcommittee on Energy
"The Electric Grid of the Future"
June 7, 2018

Good afternoon and thank you Chairman Weber for holding this important hearing. I would also like to thank this distinguished panel of witnesses for being here today.

Just last week, a White House memo was leaked that raises several questions. It detailed a plan to direct the Energy Secretary to use authorities vested in him from the Federal Power Act and the Defense Production Act to save money-losing coal and nuclear power plants. Section 202 of the Federal Power Act has historically been used to address energy supply concerns related to natural disasters or other major energy shortages. Likewise, the Defense Production Act is a Cold War-era statute that allows the President to nationalize elements of U.S. industry in the interest of national security. This proposal has been roundly criticized by a wide range of trusted, independent experts as poorly justified and legally dubious.

Our utilities, states, and researchers do the hard work of hardening our energy infrastructure to cybersecurity threats and natural disasters. Meanwhile, the Trump Administration is inventing emergencies to bail out uneconomic coal and nuclear plants while ignoring the real problems.

I am sure the White House views this legal loophole that surfaced in the leaked memo as an easy way to fulfill the President's campaign promise of bringing back coal. However, the real impact has not been thought through by the administration. It would wreak havoc on our energy markets and create a number of misaligned incentives.

As severe weather driven by climate change becomes more intense and damaging to the electric grid, this Administration wants to address that problem by offering financial bailouts to money-losing coal plants. Coal plants, I'll note, that have always been the heaviest CO_2 emitters in the power sector. Any reasonable person would agree that this seems backwards. Moreover, it wouldn't do anything to make the electric grid more resilient. The grid experts that have examined the issue would characterize our nation's priorities far differently than this politically motivated administration does. This is why FERC unanimously rejected Secretary Perry's last proposal to bail out uneconomic coal and nuclear plants.

While the Trump Administration works with coal CEOs to craft a plan to benefit the industry's bottom dollar, the American people are being left behind.

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Thank you again to the witnesses for being here. Thank you, Mr. Chairman. I yield back.

Chairman WEBER. Thank you. I'm not sure what you said in German, but I did speak with Joe a few weeks back about them going over there and told him he needs to learn to speak German, but, more importantly, since they're thinking about starting a family, he better learn to speak wife. I'm just saying. So thank you, Mr. Veasey.

I now recognize the Chairman of the full committee, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman.

The Subcommittee today is going to examine the Department of Energy's effort to modernize the electrical grid, and I very much look forward to hearing what our witnesses have to say on that subject.

DOE, our national laboratories, and universities across the country are working to develop next-generation technologies that will make up our future electric grid. This critical research and development will help address vulnerabilities that range from cyberattacks to natural disasters.

Another challenge is developing grid-scale battery storage and incorporating that into our electric grid. Renewable energy and distributed energy resources are changing the way electricity is produced and delivered throughout the nation. These energy sources are intermittent and depend on the sun to shine and the wind to blow. Without the capacity to efficiently store the energy produced from renewable energy, these resources can only make a minimal contribution to America's electricity needs. Energy storage is the key to modernizing the grid without sacrificing reliability.

My home State of Texas offers a ready example of the impact battery storage could have on harnessing renewable power. Texas is the top wind-producing State in the country, so it's no surprise that Sandia National Laboratory chose to partner with Texas Tech University on a wind-energy field testing site in Lubbock, Texas. The Scaled Wind Farm Technology Facility, or SWiFT, brings together academia, industry, and the expertise found only at the national laboratories to test and develop wind energy technology. While SWiFT's primary objectives are to improve wind turbine performance and the efficiency of wind energy production, SWiFT also provides a testbed for supporting wind power with battery technology.

Researchers at SWiFT are testing different battery chemistries and designs to harness the power of wind energy on demand. Breakthroughs in grid-scale battery storage technology will help incorporate renewable energy resources into the nation's energy mix. But scaling up batteries will necessitate addressing cost, efficiency, and size limitation problems. DOE research and development can provide these solutions and build the foundation for the next fundamental breakthrough in modern grid technology.

And DOE continues to prioritize the Grid Modernization Initiative, a crosscutting research program that harnesses the skillsets of individual labs to develop new grid technologies. At Los Alamos National Laboratory, home to one of today's witnesses, researchers are developing new power system designs that will improve the reliability and resiliency of the grid. With the technical expertise developed through its nuclear weapons program, Los Alamos uses ap-

plied mathematics and advanced modeling capabilities to research multiple energy resource delivery systems.

The national laboratories are also home to the Joint Center for Energy Storage Research Energy Innovation Hub. The DOE hub brings scientists, engineers, and manufacturers together in order to develop transformative energy storage technologies. H.R. 589, the *DOE Research and Innovation Act*, has passed the House and authorizes the Department of Energy Energy Innovation Hub program to continue this important collaborative research effort. By developing a better battery, national labs and universities can help the private sector lead the way and bring battery storage technology to the energy marketplace. This early-stage research will help create a modern, reliable, resilient grid, and that's what we all need in this country.

Thank you, Mr. Chairman, and I'll yield back.

[The prepared statement of Chairman Smith follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
June 7, 2018

Media Contacts: Thea McDonald, Bridget Dunn
(202) 225-6371

Statement by Chairman Lamar Smith (R-Texas)

The Electric Grid of the Future

Chairman Smith: Today, the Subcommittee on Energy will examine the Department of Energy's (DOE) effort to modernize the electrical grid.

DOE, our national laboratories and universities across the country are working to develop next generation technologies that will make up our future electric grid. This critical research and development will help address vulnerabilities that range from cyberattacks to natural disasters.

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The national laboratories are also home to the Joint Center for Energy Storage Research (J-CESR) Energy Innovation Hub.

This DOE hub brings scientists, engineers and manufacturers together in order to develop transformative energy storage technologies. H.R. 589, the DOE Research and Innovation Act, has passed the House and authorizes the DOE Energy Innovation Hub program to continue this important collaborative research effort.

By developing a better battery, national labs and universities can help the private sector lead the way and bring battery storage technology to the energy marketplace.

This early-stage research will help create a modern, reliable and resilient grid.

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Chairman WEBER. I thank the gentleman for yielding back.

It is now my distinct privilege to yield to the Ranking Member of the full committee, Ms. Johnson.

Ms. JOHNSON. Thank you very much, Mr. Chairman. Let me get my breath.

Let me thank all the witnesses for being here today. DOE's Office of Electricity support programs that are critical to improving the flexibility and reliability to our electric grid while also enabling a broad range of clean energy resources to play a far larger role in our nation's power and transportation sectors. This is another reason that I'm so concerned about the Administration's budget proposal for the Department, which would cut funding for this office by 37 percent, and that overall cuts includes 62 percent cut to clean energy transmission and reliability, a 74 percent cut to smart grid research, and an 81 percent energy storage R&D.

Despite the fact that Secretary Perry has now referred to energy storage as the Holy Grail of energy in several Congressional hearings, these large proposed cuts to energy reliability and resilience research are also curious in light of several recent proposals made by the Secretary to take unprecedented urgent actions that would prop up uneconomic power plants under the guise of ensuring the reliability and resilience of our electric grid.

Independent experts across the political spectrum have resoundedly rejected these proposals in favor of far more rigorous, well-justified approach to addressing these issues, while continuing to make substantial progress toward our nation's clean energy future. And I believe Mr. Gramlich will be able to discuss more—in more detail. There's no reason that we can't have a secure, clean, reliable, and resilient energy sector that takes advantage of a broad range of our resource and technology options, including renewables, energy storage, nuclear power, and fossil fuels with carbon capture without going to such an extreme of ill-conceived lengths to save one particular resource at the expense of the others.

Lastly, I'd like to take this opportunity to note sadly that this will be the Committee's last hearing staffed by Joe Flarida at least for now. He will—he's worked for us over the last five years, started out as an intern, and rising to become one of the top staffers of our Energy Subcommittee team. He's done an outstanding job. He's the son of a nurse. He's a highly professional—he's done highly professional work throughout his time on the Committee, including developing several substantive, well-vetted, bipartisan legislative proposals that I'm confident will continue to advance even as he moves to bigger and better things.

He's leaving because he's won the prestigious Bosch Foundation Fellowship. In a few weeks, he'll be moving to Germany for one year. And I'd like to congratulate you, Joe, and wish you well and hope you'll come back to see us after you've made our country proud.

I thank you, Mr. Chairman. I yield back.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson (D-TX)
Committee on Science, Space, and Technology

The Electric Grid of the Future
Energy Subcommittee Hearing
June 7, 2018

Thank you, Mr. Chairman for holding this hearing, and I would like to thank each of the witnesses for being here today.

DOE's Office of Electricity supports programs that are critical to improving the flexibility and reliability of our electric grid, while also enabling a broad range of clean energy resources to play a far larger role in our nation's power and transportation sectors.

This is another reason that I am so concerned about the Administration's budget proposal for the Department, which would cut funding for this office by 37 percent. And that overall cut includes a 62% cut to clean energy transmission and reliability, a 74% cut to smart grid research, and an 81% energy storage R&D – despite the fact that Secretary Perry has now referred to energy storage as the "holy grail" of energy in several Congressional hearings.

These large proposed cuts to energy reliability and resilience research are also curious in light of several recent proposals made by the Secretary to take unprecedented, urgent actions that would prop up uneconomic power plants under the guise of ensuring the reliability and resilience of our electric grid. Independent experts across the political spectrum have resoundingly rejected these proposals in favor of a far more rigorous, well-justified approach to addressing these issues, while continuing to make substantial progress toward our nation's clean energy future.

As I believe Mr. Gramlich will be able to discuss in more detail, there is no reason that we can't have a secure, clean, reliable, and resilient energy sector that takes advantage of a broad range of our resource and technology options, including renewables, energy storage, nuclear power, and fossil fuels with carbon capture, without going to such extreme, ill-conceived lengths to save one particular resource at the expense of the others.

Lastly, I would like to take this opportunity to note that, sadly, this will be the Committee's last hearing staffed by Joe Flarida – at least for now. Joe has worked for us for over 5 years, starting out as an intern and rising to become one of the top staffers on our Energy Subcommittee team. Joe has done outstanding, highly professional work throughout his time on the Committee, including developing several substantive, well-vetted, bipartisan legislative proposals that I am confident will continue to advance even as he moves on to bigger and better things. Joe is leaving because he's won the prestigious Bosch Foundation Fellowship, and in a few weeks he will be moving to Germany for a year. Joe, I'd like to congratulate you, wish you well, and say that I know you'll do our country proud.

With that I yield back.

Chairman WEBER. The gentlelady yields back, and I do echo her comments. Can we all give Joe a hand?

[Applause.]

Chairman WEBER. I will introduce the witnesses. Our first witness today is Hon. Bruce Walker, the Department Of Energy's Assistant Secretary for the Office of Electricity and the Acting Assistant Secretary for the Office of Cybersecurity, Energy Security, and Emergency Response. Assistant Secretary Walker has more than 25 years of electric utility experience, previously working as the Vice President of Asset Strategy and Policy at National Grid and Director of Corporate and Emergency Management at Consolidated Edison of New York. He is the founder of Modern Energy Insights, Inc., and the cofounder of Global Smart Grid Federation. Assistant Secretary Walker has served as a member of DOE's Electricity Advisory Committee, an advisory committee for the Megawatt-Scale Integration Lab, and was a member of GridWise Alliance, Incorporated.

He was confirmed as Assistant Secretary by the United States Senate in October of 2017. He holds a bachelor of electrical engineering from Manhattan College and a juris doctorate in law from Pace University where he was the technical editor on the Environmental Law Review. Welcome, Mr. Walker.

Our next witness is Dr. John Sarrao—am I saying that right? Okay—the Principal Director for Science, Technology, and Engineering at Los Alamos National Laboratory. Previously, Dr. Sarrao was the Program Director for Los Alamos Office of Science Programs and Matter-Radiation Interactions in Extremes facility. From 2013 to 2018, he served as LANL's Associate Director for Theory, Simulation, and Computation where he applied science-based predictions to existing and emerging national security missions.

Dr. Sarrao has held a number of leadership positions within LANL's materials community, including Division Leader of the Materials, Physics, and Application Division and Group Leader of Condensed Matter and Thermal Physics. He has also served on a number of DOE Basic Energy Sciences Advisory Committees (BESAC) subcommittees, helping to set strategic directions for materials research.

Dr. Sarrao is a Fellow of the American Association for the Advancement of Science, the American Physical Society, and Los Alamos National Laboratory. He received his Ph.D. in physics from the University of California Los Angeles. Welcome, Doctor.

Mr. Rob Gramlich, our next witness, is President of Grid Strategies, LLC. Prior to his current position, Mr. Gramlich oversaw transmission policy at the American Wind Energy Association as Senior Vice President for Government and Public Affairs, Interim CEO, and Policy Director. He was Economic Advisor to FERC Chairman Pat Wood, III, from 2001 to 2005. He has served on advisory committees for the United States Department of Energy and the North American Energy Standards Board as Vice Chair of the Business Council for Sustainable Energy and as Interim Executive Director of the Wind Energy Foundation.

Mr. Gramlich has been the recipient of Energy Systems Integration Group Award, American Wind Energy Association's Technical

Achievement Award, and the FERC's Exemplar of Public Service Award. He received a bachelor of arts with honors in economics from Colby College and a master of public policy from the University of California Berkeley. Welcome, Mr. Gramlich.

I now recognize the Chairman of the full Committee, Mr. Smith, to introduce our last witness.

Chairman SMITH. Okay. Thank you, Mr. Chairman. I appreciate being able to introduce our last witness today, and that is Dr. Joseph Heppert, who is Vice President for Research at Texas Tech University. It so happens that my district includes Fredericksburg, Texas, which has a satellite campus of Texas Tech with about 200 students, and believe me, I leverage that to the maximum extent possible.

We are glad to welcome Dr. Heppert today to hear about how Texas Tech is contributing to research that benefits the electric grid. Previously, Dr. Heppert served as Associate Vice Chancellor for Research at the University of Kansas. He also chaired KU's Chemistry Department and was the founding Director of the University Center for Science Education.

Dr. Heppert has been active in projects to improve science teaching and science teacher preparation and is the past Chair of the American Chemical Society's Committee on Education. He is a fellow of the American Chemical Society and currently serves as Chair of the American Chemical Society's Committee on Budget and Finance.

Dr. Heppert received a bachelor of science in chemistry from San Jose State University and a Ph.D. in inorganic chemistry, often thought to be the toughest subject, from the University of Wisconsin Madison.

Dr. Heppert, we welcome you and appreciate what Texas Tech is doing.

I yield back, Mr. Chairman.

Chairman WEBER. Thank you, Mr. Chairman, and thank you to all the witnesses for being here today.

I now recognize Assistant Secretary Walker for five minutes to present his testimony.

TESTIMONY OF THE HONORABLE BRUCE J. WALKER, ASSISTANT SECRETARY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, DEPARTMENT OF ENERGY; ACTING ASSISTANT SECRETARY, OFFICE OF CYBERSECURITY, ENERGY SECURITY, AND EMERGENCY RESPONSE, DEPARTMENT OF ENERGY

Mr. WALKER. Thank you, Chairman. Chairman Weber, Chairman Smith, Ranking Member Veasey, and Ranking Member Johnson, and distinguished Members of the Subcommittee, I appreciate the opportunity today to discuss the priorities and research programs within the Department of Energy's Office of Electricity and Office of Cybersecurity, Energy Security, and Emergency Restoration.

The Department of Energy is focused on ensuring that the energy infrastructure is capable of securing our national security. Therefore, the resilience and reliability of the nation's electric grid is of the utmost importance. OE and CESER collaborate with in-

dustry, academia, state and local governments, and other energy sector stakeholders on numerous research and development programs to achieve these objectives.

Using the definitions set forth in the Presidential Policy Directive 21, resilience is defined as, "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruption. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."

DOE, which is a national security agency with a comprehensive intelligence community-informed view of resilience, recognizes that the energy sector has been the main focus of cyber and physical threat attacks. I will seek to highlight the actions we at DOE are taking to address the very real risks we face.

First, the former Office of Electricity Delivery and Reliability has been divided into two separate departments in order to significantly increase the focus commensurate with the known risk of cyber and physical threats, thereby creating the Office of Cybersecurity, Energy Security, and Emergency Response, as well as the Office of Electricity.

My office's first priority is the creation of a North American Energy System Resiliency model. This model capitalizes on previous national lab work and is being leveraged to fully understand the resiliency risks associated with operating a highly diversified, regionally isolated grid that supplies electric energy for North America. Most importantly, the model will include analysis regarding the significant interdependencies that have evolved over the last couple decades between the various energy infrastructures.

Significantly, the model will highlight where there are strategic opportunities for specific capabilities offered by certain types of infrastructure, for example, energy storage for frequency control. Most importantly, from DOE's vantage point, the model will inform national security investments that will improve our overall resiliency capability.

Another priority for OE is to revolutionize sensing technology utilization. The goal is to use high-fidelity, reasonable cost-sensing technology to integrate near real-time data into the North American grid model. We will also be able to use signature recognition and correlation modeling informed by artificial intelligence and machine-to-machine learning to significantly improve the performance of the grid. Furthermore, these efforts will enable strategic investments by highlighting system vulnerabilities and enhance the integration of distributed energy resources in the use of microgrids and energy storage.

Storage, the Holy Grail of energy, has a huge role to play in national security. There are various initiatives within DOE focused on storage from pump storage to flow batteries. There has never been a time where the availability of megawatt-scale storage has been more important. OE is pursuing storage technology capable of providing reactive and real-power control for bulk and distribution power systems, as well as frequency control.

Working with the national laboratories, OE is pursuing three high-probability capabilities: flow batteries using aqueous soluble

organics, sodium-based batteries, and rechargeables—zinc manganese dioxide batteries.

The potential contributions of storage to enhance national security across North America are astounding. OE and CESER are members of the Grid Modernization Initiative. The GMI focuses on the development of new architectural concepts, tools, and technologies that will better measure and analyze, predict, and protect the grid. Originally consisting of OE and the Office of Energy Efficiency and Renewable Energy, the GMI has been expanded to include CESER, the Office of Fossil Energy, and the Office of Nuclear Energy to ensure a coordinated and comprehensive DOE approach to R&D.

The Grid Modernization Lab Consortium is part of the GMI, and it established a strategic partnership between DOE and the national labs. We are presently defining the next multiyear plan to continue our efforts for our R&D projects within—with our labs.

In conclusion, the energy sector continues to face challenges and threats every day. The Department continues to pursue diverse yet targeted R&D projects to further enhance the resilience and reliability of our nation's grid and energy infrastructure necessary to ensure national security. The cutting-edge technologies developed at our national labs and the ongoing research and development conducted in collaboration with our public- and private-sector partners will continue to strengthen the resilience and reliability of the grid for years to come.

Thank you, and I look forward to your questions.

[The prepared statement of Mr. Walker follows:]

Written Testimony of Bruce J. Walker

Assistant Secretary, Office of Electricity

Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response

U.S. Department of Energy

Before the

Committee on Science, Space, and Technology

Subcommittee on Energy

U.S. House of Representatives

June 7, 2018

Chairman Weber, Ranking Member Veasey, and distinguished Members of the Subcommittee, I appreciate the opportunity today to discuss the research programs and priorities within the Department of Energy's (DOE or Department) Office of Electricity (OE).

The resilience and reliability of the Nation's electric grid is of utmost importance. The Office of Electricity collaborates with industry, academia, state and local governments, and other energy sector stakeholders on numerous research and development (R&D) programs to achieve these objectives. Essential to these R&D efforts are the Department's 17 National Laboratories, a preeminent federal research system. The Labs provide strategic scientific and technological capabilities that allow DOE to pursue the energy solutions of tomorrow.

Office of Electricity Delivery and Energy Reliability Reorganization

Recognizing the importance of cutting edge research and development, as well as cybersecurity, to national security, DOE announced the standup of the Office of Cybersecurity, Energy Security, and Emergency Response (CESER).

CESER is comprised of two former Office of Electricity Delivery and Energy Reliability (OE-predecessor) divisions, Infrastructure Security and Energy Restoration and Cybersecurity for Energy Delivery Systems. This reorganization allows the Department to provide greater visibility, accountability, and flexibility in safeguarding our energy infrastructure. CESER is designed to elevate coordinated preparedness and response with our partners in the private sector, as well as government at every level.

The remaining OE-predecessor divisions, Advanced Grid Research and Development and Transmission Permitting and Technical Assistance, remain in the newly renamed Office of Electricity. The reorganized OE is focused on long-term strategic and foundational R&D efforts related to the resilience and reliability of our Nation's grid necessary to ensure national security. Specifically, OE is developing strategies to ensure the viability of our defense critical energy infrastructure against various threat vectors.

Office of Electricity Priorities
All of our cutting edge research and development programs underpin several major priorities for the Office of Electricity: the advancement of grid modeling; the pursuit of megawatt scale grid storage; revolutionizing sensing technology utilization; and long-term electrical grid recovery in Puerto Rico and the U.S. Virgin Islands.

Working with stakeholders in the U.S., Canada, and Mexico, OE is developing an integrated North American Grid Model to conduct planning and contingency analysis to address vulnerabilities in the North American energy system. This analysis will incorporate all relevant assets of the integrated energy grid and identify potential infrastructure investments to improve resiliency and mitigate risks associated with energy system interdependencies. The resulting model will also allow for sequencing of events that create risk across critical infrastructure sectors and identification of key critical infrastructure interdependencies.

The advancement of energy storage is not only a focus of OE, but also one of Secretary Perry's top priorities. OE is pursuing the advancement of megawatt scale storage capable of supporting bulk and distribution power systems. In conjunction with fellow DOE Offices and our National Labs, OE will investigate and integrate latest technologies to develop a strategic approach to rapidly progressing megawatt scale storage which provides added resiliency and control capabilities.

OE is also pursuing the integration of high fidelity, low cost sensing technology for predictive and correlation modeling. The Office of Electricity will advance the use of correlation modeling developed coincident with the advancements in computing capabilities and will build upon previous work undertaken regarding predictive modeling. OE will also evaluate opportunities to integrate sensing technology into oil and natural gas (ONG) monitoring systems and determine uses for enhanced physical security, as well as opportunities to improve phasor measurement units (post-2003 installation).

Providing support to Puerto Rico and the U.S. Virgin Islands, particularly long term resiliency efforts, is paramount. We continue our coordination efforts amongst key stakeholders and contributing members to compile a technical review of options, as well as working in collaboration on efforts regarding evaluation of the Puerto Rico Electric Power Authority's future state. Additionally, OE is providing technical assistance to the Puerto Rico Industrial Development Company and other stakeholders for strategic investment in micro-grid installations for industrial corridors.

Electricity Related Research & Development Efforts
One of OE's primary R&D efforts is the Grid Modernization Initiative (GMI). The GMI focuses on the development of new architectural concepts, tools, and technologies that will better measure, analyze, predict, and protect the grid, as well as enable the institutional conditions that allow for rapid development and widespread adoption of these tools and technologies. Originally consisting of OE and the Office of Energy Efficiency and Renewable Energy, the GMI has been expanded to include CESER, the Office of Fossil Energy, and the Office of Nuclear Energy, to ensure a coordinated and comprehensive DOE approach to R&D.

The Grid Modernization Laboratory Consortium (GMLC), a part of the GMI, was established as a strategic partnership between DOE and the National Laboratories to bring together leading experts, technologies, and resources to collaborate on the goal of modernizing the Nation's grid. The GMLC allows for the sharing of networks; more efficient use of resources; improving learning and preservation of knowledge; enhanced lab coordination and collaboration; and increased regional perspective and strengthened relationships with local stakeholders and industry.

The GMI and GMLC are working together to create the Grid Modernization Multi-Year Program Plan (MYPP), a portfolio of activities to help set the Nation on a cost-effective path to a resilient, secure, and reliable grid that is flexible enough to provide an array of emerging services. The MYPP defines a vision for the modern grid and identifies key challenges and opportunities.

To enhance transmission reliability, Los Alamos National Laboratory (LANL), in conjunction with four other partners, has undertaken a project on advanced machine learning for synchrophasor technology. LANL is developing a suite of new grid-modeling aware machine learning tools to monitor the transmission grid during its normal operations and localize significant frequency events seconds after they occur. Utilizing data and tools from several sources, they will build new machine learning software to provide situational awareness, computational, and map-visualization extensions for existing software.

Another GMI research and development effort is our Resilient Distribution Systems Lab Call Awards. Announced in September 2017, funding of approximately $32 million over three years has been awarded to the GMLC and their partners to advance resilient distribution systems, focusing on advanced controls, grid architecture, integration of distributed energy resources, and emerging grid technologies at a regional scale.

One of the projects tackling these issues is the Grid Resilience and Intelligence Platform (GRIP) project. GRIP is a collaboration between the Lawrence Berkeley National Laboratory, the Stanford Linear Accelerator Center National Accelerator Laboratory, and seven universities, utilities, industry, and stakeholder partners. Its objective is to anticipate, absorb, and recover from grid events by demonstrating predictive analytics capabilities. Combining state-of-the-art artificial intelligence and machine learning techniques will allow for a quicker recovery from grid events.

As part of the Department's commitment to a resilient and reliable power grid, DOE has recently funded R&D projects that will catalyze new design elements of large power transformers (LPTs) which are critical to the Nation's power grid and represent one of its most vulnerable components. Producing LPTs that are more flexible will help the energy sector better prepare for the sharing and long-term replacement of LPTs in the event of catastrophic failure. The five projects are a collaboration between corporations, small businesses, and academic institutions in Georgia, Illinois, New York, and North Carolina to create new designs that will help produce the next generation of LPTs.

Cybersecurity Research & Development Efforts

Any discussion of resilience and reliability must include the issue of cybersecurity. In May 2018, OE released the DOE *Multiyear Plan for Energy Sector Cybersecurity (Multiyear Plan)* to improve cybersecurity and the resilience of the Nation's energy system. The plan aligns DOE's distinct roles and programs with the efforts of government, energy owners and operators, and key energy stakeholders, at all levels.

Anticipating and responding to the latest cyber threat is a ceaseless endeavor that requires dedicated resources and personnel. It is imperative to recognize today's realities: resources are limited, and cyber threats continue to increase in frequency and sophistication. To gain the upper hand, disruptive changes in cyber risk management practices must be pursued.

DOE's cyber strategy is two-fold: (1) strengthen today's energy delivery systems by working with our partners to address growing threats and promote continuous improvement, and (2) develop game-changing solutions that will create inherently secure, resilient, and self-defending energy systems for tomorrow.

Meaningful public-private partnerships are foundational to DOE's strategy. Facing an ever-evolving threat landscape requires a coordinated approach to improving risk management capabilities, information sharing, and incident response. The Federal government has also historically funded innovative research, development, and demonstration that cannot be economically justified in private-sector markets.

CESER's cybersecurity R&D program aligns activities with Federal priorities as well as the strategy and milestones articulated in the *Multiyear Plan*, which envisions resilient energy delivery control systems designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions.

The CESER cybersecurity R&D program was designed to assist energy sector asset owners by developing cybersecurity solutions for energy delivery systems through a focused research and development effort. CESER co-funds projects with industry partners to make advances in cybersecurity capabilities for energy delivery systems. These research partnerships are helping to detect, prevent, and mitigate the consequences of a cyber-incident for the energy delivery systems of today and tomorrow.

The Collaborative Defense of Transmission and Distribution Protection and Control Devices against Cyber Attacks (CODEF) project is a highly successful collaboration between ABB, Ameren, and the University of Illinois at Urbana-Champaign. CODEF provides real-time cybersecurity with power grid devices working together to validate commands and operations. It automatically detects and rejects malicious commands that could jeopardize physical grid operations, anticipates the effect of each command, and only enacts those commands that will support grid stability. The technology was demonstrated successfully in a quasi-field environment, and private sector adoption is anticipated at the conclusion of the project.

Additionally, in spring of 2018 DOE announced another energy sector cybersecurity funding opportunity. The Department anticipates providing $25 million in funding for projects in five

research areas: cybersecure communications; cybersecurity for the ONG environment; redesign for cyber-resilient architecture for the ONG and Electricity Subsector Coordinating Councils; cybersecure cloud-based technologies in the operation technology environment; and innovative technologies that enhance cybersecurity in the energy sector. The projects selected are collaborations between DOE's National Labs, industry, and academia, and will continue the cutting-edge research needed to increase the resilience and reliability of our energy subsectors.

The information utilized by DOE and its partners in furtherance of CESER's research programs and priorities is very often highly sensitive in nature. As part of DOE's responsibilities, the Department has the ability to protect information under its Critical Electric Infrastructure Information (CEII) designation authority. DOE is currently developing new administrative procedures for CEII designation. Completion of these procedures will allow DOE to access critical information needed to execute its responsibilities as the Sector-Specific Agency for Energy under Presidential Policy Directive 21. These proposed procedures are intended to ensure that stakeholders and the public understand how DOE would designate, protect, and share CEII.

Conclusion

The energy sector continues to face challenges and threats every day, both old and new alike. The Department continues to pursue varied, yet targeted, R&D projects to further enhance the resilience and reliability of our Nation's grid and energy infrastructure necessary to ensure national security. The cutting-edge technologies developed at our National Labs, and the ongoing research and development conducted in collaboration with our public and private sector partners, will continue to strengthen the resilience and reliability of the grid for years to come.

Thank you, and I look forward to your questions.

Biography of the Honorable Bruce J. Walker
Assistant Secretary, Office of Electricity
Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response
U.S. Department of Energy

Bruce J. Walker was nominated by President Donald J. Trump and confirmed by the U.S. Senate as Assistant Secretary for the Office of Electricity (OE) at the U.S. Department of Energy (DOE) in October 2017. The focus of his responsibility is to provide leadership on a national level to modernize the electric grid, enhance the security and reliability of the energy infrastructure, and facilitate recovery from disruptions to the energy supply both domestically and internationally. This is critical to meeting the Nation's growing demand for reliable electricity by overcoming the challenges of our Nation's aging electricity transmission and distribution system and addressing the vulnerabilities in our energy supply chain.

He holds a Bachelor of Electrical Engineering from Manhattan College and a Juris Doctor in Law from Pace University where he was the technical editor on the Environmental Law Review and received an Environmental Law Certificate. He has completed the Distribution Systems program from Siemens – Power Technologies International. He is a distinguished graduate of the United States Air Force Academy Preparatory School and received an Honorable Discharge from the United States Military Academy.

Chairman WEBER. Thank you, sir.
Dr. Sarrao, you're recognized for five minutes.

**TESTIMONY OF DR. JOHN SARRAO,
PRINCIPAL ASSOCIATE DIRECTOR,
SCIENCE, TECHNOLOGY,
AND ENGINEERING DIRECTORATE,
LOS ALAMOS NATIONAL LABORATORY**

Mr. SARRAO. Chairman Weber, Chairman Smith, Ranking Member Veasey, Ranking Member Johnson, members of the subcommittee, thank you for the opportunity to address future research opportunities for the United States' electric grid and to describe the many benefits and reduced risks that would result from a more integrated, resilient, and modernized grid infrastructure.

My name is John Sarrao, and I'm the Principal Associate Director for Science, Technology, and Engineering at Los Alamos National Laboratory in New Mexico. My personal research and technical leadership career has emphasized national security science from plutonium physics research to advanced materials design and discovery to stewarding Los Alamos' high-performance computing resources and simulation capabilities.

Energy security is a national security priority, and Los Alamos National Laboratory has contributed meaningfully to energy security in general and grid resilience research in specific for many years. The challenges that today's domestic electricity grid face include the need for enhanced resilience against both natural events and external actors, robust optimization and control capability for integrating renewables, and expanded tools for grid operators to detect anomalies, including the effective utilization of machine-learning methods.

In responding to these challenges, Los Alamos brings expertise in physics and engineering, applied math and statistics, and simulation and computation. We further have a proven track record of providing mission-centric reach-back expertise in weapons physics and design, including weapons effects, high-fidelity and multiscale earth systems modeling, and space science and space weather capabilities.

Finally, Los Alamos is deeply committed to workforce development and idea dissemination, hosting a regular Grid Science Winter School and Conference to help educate and expand the grid research community.

To further support these efforts, Los Alamos has launched the Advanced Network Science Initiative, ANSI. ANSI is designed to facilitate cross-project basic and applied research that is focused on modeling and understanding the nation's critical infrastructures such as electric power, water, petroleum, and natural gas.

Given our demonstrated history in infrastructure analysis and grid research, Los Alamos was excited to participate in the Grid Modernization Laboratory Consortium, the GMLC, beginning in fiscal year 2016. The initiative has allowed a number of national laboratories to work together, bringing their complementary capabilities to bear on key challenges and delivering positive impacts for our electricity grid.

As we look to the future of grid research both under the auspices of GMLC and more broadly, Los Alamos sees several important challenges that need to be addressed: first, complex threats to U.S. power systems. U.S. power systems are potentially vulnerable to large-scale impacts from complex threats, including geomagnetic disturbances and electromagnetic pulses from a high-altitude nuclear detonation.

Second, cyber physical threats. Cyber or combined cyber and physical attacks on infrastructure can have widespread and lasting impacts on critical infrastructure. Developing a cyber-physical impact and consequences modeling and simulation capability will enable stakeholders to assess the possible consequences of different types of cyber attacks on critical infrastructure and prioritize additional investments.

Third, gas-grid coupled systems. Natural gas pipelines are a key energy infrastructure for the United States, and they are only becoming more so with the addition of supply from unconventional natural gas resources. The expansion of central-plant natural gas-fired electric generation in the electric transmission system and the expected expansion of gas-fire distributed generation in the electric distribution system would further expand that.

And fourth, grid-water network coupling and control. Potable and wastewater systems are major electrical loads that can be controlled to the benefit of both the water and electrical systems. With storage naturally built in, potable water networks are an infrastructure that could play a key role in advanced control and optimization of the electrical system. However, these water resources must also maintain their own reliability and resilience.

I appreciate the opportunity in these brief remarks to describe some of the future challenges and research opportunities for the United States' electric grid that we see at Los Alamos. Success in these endeavors would result in a more integrated, resilient, and modernized grid infrastructure. The Grid Modernization Laboratory Consortium has been a positive step forward in addressing these issues, and Los Alamos has been proud to play a role in GMLC with our peer national laboratories. As we look to the future, we see additional challenges in responding to complex threats, including cyber-physical challenges, to our grid infrastructure, and in considering the integrated systems of systems represented by our coupled gas and electrical infrastructure at both the transmission and distribution scales.

In closing, I would like to thank you again for the opportunity to appear before the Subcommittee. I look forward to answering any questions that you might have.

[The prepared statement of Mr. Sarrao follows:]

Summary of Testimony for Dr. John Sarrao

The challenges that today's domestic electricity grid faces include the need for i) enhanced resilience, against both natural events and external actors, ii) robust optimization and control capability for integrating renewables, and iii) expanded tools for grid operators to detect anomalies, including the effective utilization of machine learning methods.

In responding to these challenges Los Alamos brings expertise in physics and engineering, applied math and statistics, and simulation and computation. We also bring a mission-centric reach-back expertise in weapons physics and design, including weapons effects; high-fidelity and multi-scale earth systems modeling; and space science and space weather capabilities.

While there were naturally some growing pains in the initial definition of GMLC, the initiative has allowed a number of National Laboratories to work together, bringing their complementary capabilities to bear on key challenges and delivering positive impacts for our electricity grid. While the diversity in capabilities brought by the national laboratories is a strength of GMLC, they also previously competed with each other in some areas of grid research. As such, an early aspect of GMLC formulation was educating each other on our respective approaches to technical challenges. Initially, this can slow progress and lead to a lowest-common-denominator research approach. Fortunately, GMLC's use of peer review has ensured the best ideas are brought forward and implemented quickly.

As we look to the future of grid research, both under the auspices of GMLC and more broadly, Los Alamos sees several important challenges that need to be addressed.

First, Complex Threats to US Power Systems—US power systems are potentially vulnerable to large-scale impacts from complex threats including geomagnetic disturbances and EMP from high-altitude nuclear detonation.

Second, Cyberphysical Threats - Cyber or combined cyber and physical attacks on infrastructure can have widespread and lasting impacts on critical infrastructure. Developing modeling and simulation capabilities will enable stakeholders to assess consequences.

Third, Gas-Grid Coupled Systems - Natural gas pipelines are a key energy infrastructure for the US, and they are only becoming more so with the addition of supply from unconventional natural gas resources; the expansion of central-plant, natural gas-fired electric generation in the electric transmission system; and the expected expansion of gas-fired distributed generation in the electric distribution system.

And Fourth, Grid-Water Network Coupling and Control - Potable and waste water systems are major electrical loads that can be controlled to the benefit of both the water and electrical systems. With storage naturally built in, potable water networks are an infrastructure that could play a key role in advanced control and optimization of the electrical system.

Success in these endeavors would result in a more integrated, resilient, and modernized grid infrastructure. The Grid Modernization Laboratory Consortium has been a positive step forward in addressing these issues. As we look to the future, we see additional challenges in responding to complex threats, including cyber-physical challenges, to our grid infrastructure and in considering the integrated system of systems represented by our coupled gas and electrical infrastructure at both the transmission and distribution scale.

Prepared Statement of Dr. John Sarrao

Principal Associate Director, Science, Technology & Engineering

Los Alamos National Laboratory

For the House Science, Space & Technology Committee

Subcommittee on Energy

June 7, 2018

Chairman Weber, Ranking Member Veasey, members of the Subcommittee, thank you for this opportunity to address future research opportunities for the United States' electric grid and to describe the many benefits and reduced risks that would result from a more integrated, resilient, and modernized grid infrastructure.

My name is John Sarrao, and I am the Principal Associate Director for Science, Technology & Engineering at Los Alamos National Laboratory in Los Alamos, New Mexico. I have spent my entire professional career at Los Alamos. Prior to being appointed to my current role in April, 2018, I was Los Alamos' Associate Laboratory Director for Theory, Simulation, and Computation for the prior five years. I hold a Doctorate in Physics from the University of California, Los Angeles. My personal research and technical leadership career has emphasized national security science from plutonium physics research to advanced materials design and discovery to stewarding Los Alamos' high performance computing resources and simulation capabilities. Energy security is a national security priority, and Los Alamos National Laboratory has contributed meaningfully to energy security in general and grid resilience research in specific for many years.

Why Grid Research at Los Alamos National Laboratory

Los Alamos has a 75-year tradition of solving complex national security challenges using an interdisciplinary, team-based approach, providing solutions to decision makers. Our work in infrastructure analysis and grid research exemplifies this approach and includes our role in the National Infrastructure Simulation and Analysis Center supported by the Department of Homeland Security. Further, exercising and expanding our capabilities in these areas directly contributes to the successful performance of our core mission in stewarding the United States' nuclear deterrent.

The challenges that today's domestic electricity grid faces include the need for i) enhanced resilience, against both natural events and external actors, ii) robust optimization and control capability for integrating renewables, and iii) expanded tools for grid operators to detect anomalies, including the effective utilization of machine learning methods.

In responding to these challenges Los Alamos brings expertise in physics and engineering, applied math and statistics, and simulation and computation. We further have a proven track record of providing mission-centric reach-back expertise in weapons physics and design, including weapons effects; high-fidelity and multi-scale earth systems modeling; and space science and space weather capabilities.

Finally, Los Alamos is deeply committed to workforce development and idea dissemination, hosting a regular "Grid Science Winter School and Conference" to help educate and expand the grid research community.

To support these efforts, Los Alamos has launched the Advanced Network Science Initiative (ANSI). ANSI is designed to facilitate cross-project basic and applied research that is focused on modeling and understanding the nation's critical infrastructures, such as electric power, water, petroleum and natural gas. The initiative's expertise includes statistics, stochastic methods, machine learning, control theory, dynamical systems, discrete and continuous optimization, statistical physics, and graphical modeling. The interdisciplinary nature of ANSI ensures the scientific and technological validity of our approaches by working closely with physicists, engineers, mathematicians, statisticians, computer scientists, and economists through connections with industry, academia, and other national laboratories.

A few recent examples of Los Alamos' contributions to national energy security challenges include:

- Solar Geomagnetic Disturbances (GMD) and the science of transmission standards
    - Critical input from LANL into FERC Order 830 on GMD standards.
    - LANL's contribution called out individually by Commissioner La Fleur in Order 830
    - Working directly with industry groups (EPRI) to improve updates planning standards

- Nuclear electromagnetic pulse (EMP) effects; clarifying the threat to US power systems
    - Leading joint Department of Energy and Department of Homeland Security study to characterize nuclear EMP impacts
    - Leading interagency study to determine foreign nuclear EMP threats and impacts
    - Working directly with industry groups (EPRI) to improve modeling and simulation

- Natural Gas-Electric Power Joint Reliability—Complex reliability assessments of Southern California's coupled energy system during Aliso Canyon outage
    - Jointly worked with CalSO, SoCal Gas, and California Public Utility Commission (CPUC) to resolve complex analysis issues
    - Provided official testimony to CPUC proceedings on Aliso Canyon

Successes of the Grid Modernization Laboratory Consortium

Given our demonstrated history in infrastructure analysis and grid research, Los Alamos was excited to participate in the Grid Modernization Laboratory Consortium (GMLC), beginning in fiscal year 2016. While there were naturally some growing pains in the initial definition of GMLC, the initiative has allowed a number of National Laboratories to work together, bringing their complementary capabilities to bear on key challenges and delivering positive impacts for our electricity grid.

While the respective National Laboratories have complementary capabilities – and this diversity is a strength of GMLC, they also previously competed with each other in some areas of grid research. As such, an early aspect of GMLC formulation was educating each other on our respective approaches to technical challenges. Initially, this can slow progress and lead to a lowest-common-denominator research approach. Fortunately, GMLC's use of peer review has ensured the best ideas are brought forward and implemented quickly.

As a measure of the success of GMLC, not only are new multi-Laboratory teams working together to address grid research challenges, but also these newly formed and GMLC-inspired teams are collaborating in broader areas of research beyond the initial scope of GMLC.

Future Challenges and Opportunities for Grid Research

As we look to the future of grid research, both under the auspices of GMLC and more broadly, Los Alamos sees several important challenges that need to be addressed.

Complex Threats to US Power Systems—US power systems are potentially vulnerable to large-scale impacts from complex threats including geomagnetic disturbances and EMP from high-altitude nuclear detonation. Our understanding of the science underlying the components of these threats and their impacts on power systems has improved significantly over the last decade. Additional work is required to both provide high fidelity quantitative impact analysis to determine the scope of the concern and, where necessary, to provide improved situational awareness tools to provide input into operational responses taken by the infrastructure owners.

Cyberphysical Threats

Cyber or combined cyber and physical attacks on infrastructure can have widespread and lasting impacts on critical infrastructure. Developing a cyber-physical impact and consequences modeling and simulation capability will enable stakeholders to assess the possible consequences of different types of cyberattacks on critical infrastructure and prioritize additional investments in both impact studies and research and development into cyber-physical systems modeling and simulation.

There are also opportunities to develop new methods to jointly design cyber and physical systems to be resilient to natural and man-made threats. The objective of such an effort is to provide rigorous, optimization-based design methods to evaluate the optimal allocation of future, secure communications components (including quantum secured communications lines and associated trustworthy node relays). The goal is to utilize these methods to characterize the value of the future, advanced communications components to the resilience of electrical power systems. The results generated by this effort are threefold—rigorous mathematical models of cyberphysical components, prototype software that embodies optimal network design formulations for cyberphysical systems, and design results that characterize the resilience of different cyberphysical architectures.

Grid resilience, optimization, and disaster recovery all depend critically on having communication links that are authenticated, secure, and reliable. We at Los Alamos have a twenty-year history of developing secured communication systems by leveraging quantum science and technology. DoE Office of Electricity Delivery and Energy Reliability currently funds several LANL projects to develop and deploy quantum-secured communication hardware specifically tailored to the power industry.

Gas-Grid Coupled Systems

Natural gas pipelines are a key energy infrastructure for the US, and they are only becoming more so with the addition of supply from unconventional natural gas resources; the expansion of central-plant, natural gas-fired electric generation in the electric transmission system; and the expected expansion of gas-fired distributed generation in the electric distribution system. The economic and environmental

drivers behind this evolution will continue as the country leverages advances in the science and engineering of resource extraction. A side effect of this evolution of the US energy systems is the complex coupling between the electric power system and the "just in time" delivery of natural gas to electric generation. This coupling is necessary to leverage these new resources; however, it is also resulting in emerging technical and regulatory challenges that require foundational and applied research and development.

Gas-Grid Coupling at the Transmission Level:

1. LANL is working with our industry and commercial partners to develop intra-day, dynamical optimization and control of pipeline flow and compressor operation with the objective of developing a mathematically sound basis for advanced gas pipeline operation and potential natural gas balancing markets.
2. LANL is also working across the Department of Energy (DOE) to develop integrated models of gas-grid systems that reveal vulnerabilities in this complex, joint systems. We are working to integrate these models of vulnerability into rigorous design approaches with the objective of providing methods to industry to eliminate vulnerabilities.
3. LANL continues to work the coupled gas-grid reliability issue in Southern California. We are currently working with the California Public Utility Commission to develop methods to assess the needs for future underground gas storage to ensure the reliability of the gas pipeline systems and to provide gas supply to the regional electrical transmission and generation system.
4. LANL is leveraging DOE-funded work on gas and gas-grid systems to provide strategic analysis tools to the Defense Threat Reduction Agency, and ultimately to USSTRATCOM, to assess impacts to natural gas pipeline networks.

Gas-Grid Coupling at the Distribution Level:

1. DOE Office of Energy Efficiency and Renewal Energy projections show substantial increases in distributed generation in the form of smaller scale combined heat and power (CHP). If this trend materializes, there are potential technical challenges that may arise in natural gas distribution that mirror the challenges already evident in transmission, i.e., the ability of the gas distribution pipelines to supply the increased and more variable demand from CHP. DOE should work together with the national labs to get ahead of the design, optimization and control issues to avoid the integration issues that arose with other distributed generation technologies, such as solar photovoltaics.

Grid-Water Network Coupling and Control:

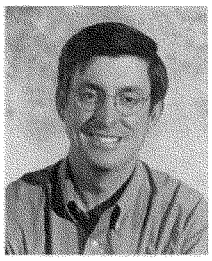
1. Potable and waste water systems are major electrical loads that can be controlled to the benefit of both the water and electrical systems. With storage naturally built in, potable water networks are an infrastructure that could play a key role in advanced control and optimization of the electrical system. However, as a critical infrastructure, these water networks must also maintain their own reliability and resilience. Balancing the needs of these complex networks in optimization and control is a key gap in enabling advanced functionality. DOE should take a more active role is developing the foundational research needed to more closely integrate these systems.

In Conclusion

I appreciate the opportunity in these brief remarks to describe some of the future challenges and research opportunities for the United States' electric grid that we see at Los Alamos. Success in these endeavors would result in a more integrated, resilient, and modernized grid infrastructure. The Grid Modernization Laboratory Consortium has been a positive step forward in addressing these issues, and Los Alamos has been proud to play a key role in GMLC with our peer National Laboratories. As we look to the future, we see additional challenges in responding to complex threats, including cyber-physical challenges, to our grid infrastructure and in considering the integrated system of systems represented by our coupled gas and electrical infrastructure at both the transmission and distribution scale.

In closing, I would like to thank you again for the opportunity to appear before the Subcommittee. I look forward to answering any questions that you might have.

JOHN L. SARRAO



As of April 2018, John Sarrao is the Principal Associate Director for Science, Technology and Engineering (PADSTE) at Los Alamos National Laboratory. As PADSTE, he leads the Laboratory's science, technology, and engineering capabilities, overseeing a $1.2B organization with 3,000 staff. PADSTE spans the Laboratory's directorates for Chemistry, Life & Earth Sciences; Engineering Sciences; Experimental Physical Sciences; and Theory, Simulation, and Computation. John stewards LANL's Laboratory Directed Research & Development (LDRD) program and other institutional capability initiatives, including the Laboratory's student and post-doc programs. He also serves as LANL's Chief Research Officer.

From 2013 to 2018, John served as LANL's Associate Director for Theory, Simulation, and Computation (AD-TSC). As AD-TSC, he led the Laboratory's efforts in applying science-based prediction to existing and emerging national security missions. TSC spans LANL's Theoretical; Computer, Computational, and Statistical Sciences; and High Performance Computing organizations. John also played a national leadership role in the Exascale Computing Project. Previously, Sarrao was the Program Director for Los Alamos's Office of Science Programs, and for MaRIE (Matter-Radiation Interactions in Extremes), LANL's signature facility concept which will provide transformational materials solutions for national security challenges.

John has held a number of leadership positions within LANL's materials community, including Division Leader of the Materials Physics and Applications Division and Group Leader of Condensed Matter and Thermal Physics. John has also served on a number of U.S. Department of Energy Basic Energy Sciences Advisory Committee (BESAC) Subcommittees, helping to set strategic directions for materials research.

John's primary research interest is in the synthesis and characterization of correlated electron systems, especially actinide materials. He was the 2013 winner of the Department of Energy's E.O. Lawrence Award and the 2004 winner of the LANL Fellows Prize for Research, in part for his discovery of the first plutonium superconductor. He is a Fellow of the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), and Los Alamos National Laboratory. John received his Ph.D. in physics from the University of California, Los Angeles based on thesis work performed at LANL.

Chairman WEBER. Thank you, Doctor.
Mr. Gramlich, you are recognized for five minutes.

TESTIMONY OF MR. ROBERT GRAMLICH, PRESIDENT, GRID STRATEGIES, LLC.

Mr. GRAMLICH. Thank you, Chairman Weber, Ranking Member Veasey, and Members of the Subcommittee, for inviting me to testify on the electric grid of the future.

Since modern society requires affordable, clean, and reliable electricity for most commercial and personal pursuits, there is no infrastructure more important than the interstate electric network. While reliability is very high and growing, as reported by NERC just today over at FERC across town, the grid is evolving rapidly and threats are changing. We need to expand grid capacity, implement protections against severe weather and cyber and physical attack, and make more efficient use of the existing grid.

DOE's Office of Electricity (OE) can play a key role in each of these areas. OE can contribute by continuing research development and demonstration of new technologies for the grid, promoting grid expansion through permitting and studies, developing and bringing grid operations technologies to market, developing customer and reliability and resilience options for critical uses such as military facilities and hospitals, and supporting studies of bulk power system reliability to address the evolving resource mix and evolving threats.

The National Academies of Sciences recently had a resilience report that had 12 recommendations. Eight of those were for DOE. OE could play a lead role in implementing those recommendations.

Given the importance of a reliable electric grid to modern society and the critical role it plays in integrating new both centralized and distributed resources and managing various threats, OE should have far greater resources than it has. At the same time, OE resources and attention should not be diverted to support the recently announced presidential directive to extend the lives of old coal and nuclear plants. Subsidizing such resources will ultimately harm rather than help customers, and OE's work on it will detract from its otherwise important mission.

There is no basis for this directive or for DOE action under the Federal Power Act, section 202(c); or the Defense Production Act. The directive ignores some basic facts about electricity. It ignores that coal and nuclear plants are just as susceptible to cyber attack as any other facility. It ignores the fact that coal plants have fuel delivery interruptions and often have mechanical failures during cold weather. It ignores the fact that both coal and nuclear plants are particularly vulnerable to droughts, and there is some evidence to suggest EMP attacks as well. And it ignores that coal and nuclear plants shut down in response to voltage infrequency deviations and a narrower band of tolerance than, for example, wind plants. This is actually what happened in the 2003 blackout affecting 50 million people when a large FirstEnergy coal plant automatically shut itself down.

The point here is not to—oh, I should also say the directive ignores that 50-year-old plants have outage rates that are typically three times as high as new plants. So the point here is not to criti-

cize any one technology or couple of technologies. All technology, all generating resources have their strengths and weaknesses and contribute to reliability and resilience in different ways, but none of them are essential.

Reliability comes from having reserves. All generators fail to operate at some point. In fact, each region already has a strategic electric generation reserve. It's called a reserve margin, and they are in a significant surplus condition right now in most regions. So whether or not there are national security interests at stake, the proposed solution will not help.

Due to the futility of this directive, OE should steer clear of it and focus on what matters for electricity customers. OE's modeling to support the bailout plan should be scrutinized carefully so that resources are not diverted from valuable work on reliability, resilience, efficiency, and the grid's evolution, given changes in the resource mix and evolving threats. It will be important for Congress to rigorously oversee the Department of Energy and OE specifically to ensure that important work gets done and taxpayer dollars are not wasted on ill-conceived programs.

Thank you.

[The prepared statement of Mr. Gramlich follows:]

Grid Strategies LLC

TESTIMONY OF ROBERT E. GRAMLICH

PRESIDENT, GRID STRATEGIES LLC

US HOUSE OF REPRESENTATIVES

HOUSE SCIENCE COMMITTEE

ENERGY SUBCOMMITTEE

Hearing entitled "The Electric Grid of the Future"

June 7, 2018

Thank you, Chairman Weber, Ranking Member Veasey, and Members of the Sub-Committee for inviting me to testify on the electric grid of the future. Since modern society requires affordable, clean, and reliable electricity for most commercial and personal pursuits, there is no infrastructure more important than the interstate electric network.

I serve as Executive Director of the WATT Coalition (Working for Advanced Transmission Technologies), on the board of the Americans for a Clean Energy Grid coalition, and have a consulting practice called Grid Strategies LLC that provides analysis and regulatory policy support for clean energy integration and delivery. I have served as a member of the Electricity Advisory Committee of the DOE Office of Electric Delivery and Energy Reliability from 2008 through 2012, as Senior Vice President of the American Wind Energy Association, as Economic Advisor to FERC Chairman Pat Wood III, and as a Senior Economist at PJM Interconnection LLC.

I. The power system has never been more reliable and no emergency exists

The grid is currently very reliable. There is no crisis or emergency. The grid is experiencing rapid changes as more clean, low-cost resources come on-line to serve customers and crowd out higher-cost, less flexible generation, at the same time that Americans' demand for electricity is flattening. There are also some new and emerging threats that should be addressed, as there always are over time. Reliability and grid authorities are on top of these issues.

DOE and its Office of Electricity can best support reliability and resilience through continuing RD&D, promoting grid expansion and innovations to better use the existing grid, and by following through on recommendations from expert sources such as grid operators, national laboratories, and the National Academies of Science, Engineering & Medicine. The Department should refrain from pursuing misguided support for certain favored generators and

technologies, since such subsidies will ultimately harm rather than help customers -- including defense facilities and taxpayers – and harm rather than improve overall grid reliability, security, flexibility and costs.

Over the past decade, authorities including the Department of Energy have consistently reported that the electric system is reliable and becoming more reliable. The North American Electric Reliability Corporation (NERC) reported through its then-CEO to the Federal Energy Regulatory Commission (FERC), "I am pleased to report that the state of reliability in North America remains strong, and the trend line shows continuing improvement year over year."[1] In the region with the most recent and potential future retirements of coal and nuclear plants, grid operator PJM stated, "Our analysis of the recently announced planned deactivations of certain nuclear plants has determined that there is no immediate threat to system reliability."[2] PJM continued, "The PJM electrical grid is more reliable than ever, with 23 percent reserve margins and billions of dollars of new investment. All of this is occurring while emissions are decreasing and wholesale prices are at historic lows for the 65 million consumers we serve. From 2008 to 2017, wholesale prices in PJM fell by more than 40 percent. Competition has required generators to operate more efficiently while also attracting new, more efficient technology, resulting in more than $1.4 billion in annual savings."[3]

Competitive power markets have been key to continued and growing reliability. PJM stated, "Markets have helped to establish a reliable grid with historically low prices. Any federal intervention in the market to order customers to buy electricity from specific power plants would be damaging to the markets and therefore costly to consumers."[4]

II. The electric sector faces evolving threats and opportunities

The electric sector faces a new set of challenges every decade. In the 1990s the industry introduced competition through open access transmission, independent regional grid operation, and the development of an independent power producer sector. In the 2000s, the industry reversed the prior downward trend in infrastructure investment to build up transmission and distribution capability across the country, and implemented mandatory reliability standards after the 2003 Northeast blackout.[5]

This decade seems to have two major defining characteristics: the opportunity to use more low-cost wind, solar, batteries, and natural gas, and the growing threats from severe weather and cyber and physical attack.

Renewable energy costs have fallen by over two-thirds this decade, so it is certain that wind and solar use will continue to grow based on favorable economics regardless of public policy on

[1] https://www.ferc.gov/CalendarFiles/20170717080645-Cauley,%20NERC.pdf p.1.
[2] http://www.pjm.com/-/media/about-pjm/newsroom/2018-releases/20180601-pjm-statement-on-potential-doe-market-intervention.ashx
[3] http://www.pjm.com/-/media/about-pjm/newsroom/2018-releases/20180601-pjm-statement-on-potential-doe-market-intervention.ashx
[4] http://www.pjm.com/-/media/about-pjm/newsroom/2018-releases/20180601-pjm-statement-on-potential-doe-market-intervention.ashx
[5] http://www.eei.org/issuesandpolicy/transmission/Documents/Trans_Project_lowres_bookmarked.pdf

renewable energy or climate. This presents major opportunities for customers and utilities. It also creates new operational and planning issues related to variability, handling inverter-based technologies, and maintaining stability in some of the weaker parts of the grid. These challenges can be overcome in a safe and economical manner. Over the past decade we have moved from conventional wisdom that 5 percent annual energy from variable sources was a problem, to understand that a mix with 20 percent or more renewable energy is not a major grid management problem.[6] Some systems such as Ireland, even as an electrical island, are evaluating variable resource penetrations of up to 80 percent. Managing a system with high renewable penetration entails changes in system planning and operations, but this nation and others have been working successfully for the past decade to understand the challenges and develop effective solutions.

There is an increasing focus on resilience to certain threats. The Executive Office of the President issued a report on electric system resilience in 2013[7] and the National Academies of Sciences (NAS) did the same in 2017.[8] Severe weather events are growing in magnitude and frequency. Power systems have been challenged not only by Hurricanes Maria, Irma, Harvey, Matthew, Irene and Sandy, but also prolonged cold spells in the Northeast, drought in the South and West, ice storms in the Central region, and wildfires in the West. Intentional physical and cyber attacks are also increasingly plausible, and merit inclusion in reliability frameworks and standards. The NAS report concludes, "the risks of physical or cyber attacks pose a serious and growing threat,"[9] and the Department of Energy and others have been documenting these threats and recommending solutions. It is appropriate for NERC and other reliability authorities to undertake analyses of any new issues or risks as the power system changes, and they are doing so with respect to physical and cyber security, geomagnetic disturbances, and other operational threats.

An analysis of resilience which I recently co-authored offers some broad conclusions:[10]

1) Most outages are caused by distribution problems, not generation or fuel supply, and by routine rather than large events;

2) Budgets are limited, and investments have opportunity costs – suggesting policy makers should compare actual reliability and resilience impact per dollar spent, such as on measures that address multiple threats;

3) Spending to protect high levels of generation capacity (especially older, inflexible units with poor ride-through capability) yields little benefit, while spending on measures close to customers, such as distribution system hardening and critical spares for transmission

[6] For example, see https://www.weforum.org/agenda/2017/02/wind-power-has-crossed-a-significant-milestone-in-the-us

[7] https://www.energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf

[8] https://www.nap.edu/read/24836/chapter/1

[9] https://www.nap.edu/read/24836/chapter/3#12

[10] Silverstein, Gramlich, Goggin, "A Customer-Focused Framework for Electric System Resilience," https://gridprogress.files.wordpress.com/2018/05/customer-focused-resilience-final-050118.pdf .

equipment, protects against a wide variety of threats and contributes more to reliability and resilience.

III. Grid needs and opportunities

The evolving resource mix and threat environment calls for attention from policy makers in certain general areas: bulk transmission infrastructure, customer-specific reliability for critical electricity needs, distribution system hardening, bulk transmission operations, developing flexible resources, distributed generation and storage, energy efficiency that protects customer survival during extended outages, and analysis and models to support inverter-based generation penetration. Generally these initiatives can be funded by ratepayers through federal and state regulatory policy (FERC and state public utility commissions), so there are very high leverage opportunities available today and emerging from federal and private sector research into better technologies and methods for power system infrastructure and operations.

A. Bulk transmission infrastructure

The transmission network is critical for reliability, resilience, efficiency, and connecting and integrating new clean energy resources. I shared a set of ideas recently at a House Energy and Commerce Committee hearing on opportunities to expand transmission.[11]

Two opportunities in particular are inter-regional planning and cost allocation to increase power flow capability between regions, and high-voltage Direct Current (DC) lines using voltage-source converter (VSC) technology. Unlike the line-commutated converter (LCC), the VSC can supply reactive power; go from no-load to full load, or reverse power flow direction, in 3 cycles instead of seconds; and black-start an area.

We must reform how transmission is planned and paid for -- particularly inter-regional transmission -- to break the current logjam limiting private investment in our grid. FERC has the authority to reform these policies, and should do so. Inter-regional transmission improves reliability and resilience and more than pays for itself by giving customers and regions access to lower-cost, diverse sources of energy.[12] Inter-regional transmission also increases power system efficiency by aggregating diverse sources of supply and demand.[13]

B. Customer-specific reliability for critical electricity needs

Some customers highly value reliable electricity. The value of uninterrupted service for water treatment plants, emergency first responders, hospitals, nursing homes, military facilities, some industrial facilities, data centers, and other critical facilities is much higher than for other customers.[14] The most cost-effective solution for increasing reliability and resilience for these customers is to deploy reliability solutions like backup generators and storage, at the customer

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[11] https://docs.house.gov/meetings/IF/IF03/20180510/108283/HHRG-115-IF03-Wstate-GramlichR-20180510.pdf
[12] https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf, https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf
[13] http://www.sciencemag.org/news/2016/01/better-power-lines-would-help-us-supercharge-renewable-energy-study-suggests, https://arpa-e.energy.gov/sites/default/files/ARPA-E%20Dale%20Osborn.pdf
[14] http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=24836

site. As stated by Argonne National Laboratory and quoted in the DOE Quadrennial Energy Review, ""One hundred percent of the following assessed facility groups have an alternate or back [-up] power in place: Banking and Finance; Critical Access Hospitals; Private or Private Not-for-Profit General Medical and Surgical Hospitals; State, Local, or Tribal General Medical and Surgical Hospitals."[15]

Around 90% of outages at military facilities result from failures of equipment on the base.[16] These failures should be a primary focus of efforts to increase bases' electric reliability and resilience, including[17]:

- Increased maintenance of electrical distribution equipment serving the base (52% of base outages are caused by equipment failures).[18]
- Vegetation management to keep trees from contacting power lines serving the base (30% of base outages are caused by weather).
- Adding healthy redundancy by converting radial lines to looped networks.
- Undergrounding critical circuits.
- Investing in more backup generators and Uninterruptible Power Supplies for critical loads.
- Spare transformers and substations.
- Better maintenance and regular testing of backup generators to reduce the high rate of backup generator startup failures (only 60% of military facilities are compliant with requirements for "testing/exercising;" one senior military official noted that, "Maintenance of generators is underfunded and no one checks.").[19]
- Develop refueling plans for backup generators (only 84% of facilities are compliant).
- Microgrids can increase base resilience by aggregating the base's backup generators and loads, protecting against failures of individual backup generators;[20] this requires also hardening the base's distribution equipment, which must be intact for a microgrid to be able to share power across the base.

C. Distribution system hardening

Over 90 percent of customer outages are due to distribution system failures.[21] That share is likely to grow as severe weather threats increase, because the distribution system is more

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[15] DOE QER at 4-46, and Julia Philips, Kelly Wallace, Terence Kudo, and Joseph Eto, Onsite and Electric Power Backup Capabilities at Critical
Infrastructure Facilities in the United States (Argonne, IL: Argonne National Laboratory, 2016), ANL/GSS-16/1, https://emp.lbl.gov/sites/all/files/onsite-and-electric-power-backup.pdf

[16] https://www.gao.gov/assets/680/671583.pdf

[17] See DOE QER at p. 4-46.

[18] https://www.acq.osd.mil/eie/Downloads/IE/1%20-%20Castillo%20DoD%20Energy%20Resilience%20Overview_Aug%202015.pdf, page 3

[19] http://www.pewtrusts.org/~/media/assets/2017/01/ce_power_begins_at_home_assured_energy_for_us_military_bases.pdf, pages 10-11

[20] *Ibid.*

[21] U.S. DOE, Quadrennial Energy Review, Second Installment, Chapter IV, p. 4-2 and 4-29

affected by severe weather and many natural disasters than transmission or generation infrastructure. Utilities and state regulators have principal responsibility for distribution system investments. DOE and the national laboratories can develop and share technologies, modeling techniques, and best practices for improving distribution system reliability and resilience.

D. Bulk transmission operations

As with most other forms of infrastructure, advances in monitoring and control systems can improve the reliability and efficiency of the transmission network. There is a set of cost-effective technologies that can increase the flexibility, reliability and utilization of the existing grid.[22] Technology options which can be used separately or together include dynamic line ratings,[23] advanced power flow control,[24] synchrophasor monitoring and analytics, and transmission topology optimization.[25]

E. Expanding flexible resources

Any increase or decrease in system load or generation requires system operators to ramp up or down other resources to keep supply and demand in balance at all times of day and throughout the year. Increasing penetrations of variable resources can make flexible resources that are able to respond to such system balancing needs more valuable. These include demand-side resources such as building energy management, demand response and customer-sited energy storage as well as flexible supply-side resources such as gas turbines, renewables resources themselves, and storage. System operators and market designers should remove barriers that block such flexible resources from participating in markets for flexibility services or from delivering such services in the 40% of the nation that does not have centralized competitive power markets.

F. Analysis and models to support inverter-based generation penetration

Some of the new technologies integrating into the grid such as wind, photovoltaics, and batteries are "non-synchronous," such that power electronics are used to integrate them into the bulk power system. This brings opportunities to improve reliability, such as through extremely fast response to support frequency deviations. However, these resources operate

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https://www.energy.gov/sites/prod/files/2017/02/f34/Chapter%20IV--Ensuring%20Electricity%20System%20Reliability%2C%20Security%2C%20and%20Resilience.pdf

[22] https://watttransmission.files.wordpress.com/2018/03/watt-living-grid-white-paper.pdf

[23] Dynamic Line Ratings (DLR) increase capacity on existing transmission lines by calculating capacity ratings based on actual monitored conditions rather than fixed worst-case assumptions. See DOE QER https://www.energy.gov/sites/prod/files/2017/02/f34/Chapter%20IV--Ensuring%20Electricity%20System%20Reliability%2C%20Security%2C%20and%20Resilience.pdf p. 4-44.

[24] Power Flow Control refers to a set of technologies that effectively push or pull power away from overloaded lines and onto underutilized corridors within the existing transmission network. Advanced power flow control provides this same function with advanced features such as the ability to quickly deploy, easily scale to meet the size of the need, or redeploy to new parts of the grid when no longer needed in the current location.

[25] Transmission topology optimization is a software technology that automatically identifies reconfigurations of the grid to route power flow around congested or overloaded transmission elements, taking advantage of the meshed nature of the power grid.

differently than traditional synchronous machines and their settings need to be properly set to improve system reliability and not harm it. This is particularly true on "weak" systems (where there is a high sensitivity of local system voltage to variations in current injections), which tends to occur in remote areas where the best renewable resource areas are found. NERC and RTOs are performing research in this area.[26]

IV. DOE's Office of Electricity can play a key role

DOE has contributed a great deal to advances in transmission hardware, monitoring and control systems, and sensor development and deployment. Given the importance of a reliable electric grid to modern society, and the critical role it plays in integrating new centralized and distributed resources and managing various threats, the Office of Electricity (OE) needs full funding.

A. Continue and Expand Research, Development, and Demonstration

OE can contribute through its Grid Modernization Initiative (GMI).[27] I agree with the office's focus on reliability, flexibility, efficiency, resiliency, affordability and security,[28] and the general direction of the GMI.

I would emphasize the opportunities to demonstrate and evaluate some of the technologies DOE has helped foster. The technologies mentioned above -- Dynamic Line Ratings (DLR), advanced power flow control, synchrophasors, and topology optimization -- have benefited from DOE RD&D support. They can all improve reliability, resilience, and efficiency, and are extremely affordable. The challenge is getting transmission owners to use them when they generally do not have an incentive to do so. FERC has the primary authority to address that, but DOE can help by funding local and regional studies of the benefits of these technologies.

B. Support studies of the evolving generation mix

NERC and RTOs are generally aware of the opportunities and risks of shifting to more use of inverter-based resources.[29] They could benefit from DOE support for studies to better understand what standards or guidelines to use in interconnection requirements. Better system models, generic resource models, and tools are needed, and no entity can support that better than DOE. For example, studies of weak grids with high penetrations of inverter-based resources would be extremely valuable.

DOE management has been visionary for decades in imagining new energy production, delivery and use technologies and bringing them from idea into reality. These successes include hydraulic fracturing for natural gas, wind and solar technology, natural gas-fired combustion turbines, a host of energy-efficient building and appliance designs, and the smart grid. The

[26] https://www.nerc.com/pa/RAPA/rg/ReliabilityGuidelines/Reliabilty_Guideline_-_Integrating_VER_into_Weak_Power_Systems.pdf

[27] https://www.energy.gov/grid-modernization-initiative-0

[28] https://www.energy.gov/oe/activities/technology-development

[29] https://www.nerc.com/pa/RAPA/rg/ReliabilityGuidelines/Reliabilty_Guideline_-_Integrating_VER_into_Weak_Power_Systems.pdf

power system components and balance – particularly generation fleet composition -- has changed markedly in large part to these and other technology advances. DOE-OE should continue to conduct studies of how to modernize and evolve grid architecture and how to integrate distributed energy resources (DERs), to help the electric industry and society adapt to further evolution of power system capabilities and roles.

C. Perform resilience functions as recommended by NAS

In the National Academies of Sciences study of power system resilience, 8 of the 12 recommendations to policy makers were for the Department of Energy. DOE's Office of Electricity can play a lead role in implementing these eight specific recommendations:[30]

1. "Improve understanding of customer and societal value associated with increased resilience and review and operationalize metrics for resilience."
2. "Support research, development, and demonstration activities to improve the resilience of power system operations and recovery by reducing barriers to adoption of innovative technologies and operational strategies."
3. "Advance the safe and effective development of distributed energy resources and micro-grids."
4. "Work to improve the ability to use computers, software, and simulation to research, plan, and operate the power system to increase resilience."
5. "Work to improve the cybersecurity and cyber resilience of the grid."
6. "The owners and operators of electricity infrastructure should work closely with DOE in systematically reviewing previous outages and demonstrating technologies, operational arrangements, and exercises that increase the resilience of the grid."
7. "Work collaboratively to improve preparation for, emergency response to, and recovery from large-area, long-duration blackouts."
8. "With a growing awareness of the electricity system as a potential target for malicious attacks using both physical and cyber means, DHS and DOE should work closely with operating utilities and other relevant stakeholders to improve physical and cyber security and resilience."

D. Transmission expansion

OE can play a key role in assisting with the planning and permitting of high-voltage long-distance transmission. OE can help facilitate inter-regional transmission through analytical and data support, and process facilitation to resolve differences in methodologies and metrics.

OE can also perform its roles under EPAct 2005 for congestion studies and backstop federal transmission siting. I recommend DOE engage only in very specific limited circumstances when all other options have failed.

V. Budget priorities should reflect the importance of the grid and DOE's role

[30] https://www.nap.edu/read/24836/chapter/2#6

The most critical challenges for a reliable, resilient, and clean future power system lie in the integration of diverse resources into the grid, more so than the continued cost reductions or preservation of any one generation technology. Yet OE's budget is far smaller than most generation-specific or demand-side programs within DOE. This is not surprising given its relatively short program history, but Congress and the administration have a strategic opportunity to expand resources for future needs.

a. The administration's proposed budget cuts would undermine reliability and resilience

The administration's budget states, "The mission of the Office of Electricity Delivery (OE) is to drive electric grid modernization and resiliency in energy infrastructure."[31] Yet it proposes to cut approximately 2/3 to 3/4 of the funding for transmission reliability and resiliency, resilient distribution systems, and energy storage.[32]

b. The House bill removes the cuts but does not increase funding to where it should be

The House bill puts funding back up to $45 million, $48 million, and $51 million, respectively for transmission reliability and resiliency, resilient distribution systems, and energy storage (from $13 million, $10 million, and $8 million, respectively, in the administration's proposal).[33] This is an improvement relative to the Administration's proposed budget, but does not reflect the importance of the grid and DOE's key role.

VI. OE should not support the administration's misguided initiative to bail out old, unreliable power plants

On June 1, the President stated, "impending retirements of fuel-secure power facilities are leading to a rapid depletion of a critical part of our Nation's energy mix," and directed the Secretary of Energy "to prepare immediate steps to stop the loss of these resources."[34] A leaked untitled draft memo identified "fuel-secure" units as coal, nuclear, oil and dual-fueled resources with adequate storage.[35] This draft generator bail-out plan indicates that DOE has already concluded that, "recent and announced retirements of fuel-secure electric generation capacity across the continental U.S. are undermining the security of the electric power system because the system's resilience depends on those resources."[36]

There is no basis for this directive or for DOE's findings. It ignores some basic facts:

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[31] https://www.whitehouse.gov/wp-content/uploads/2018/02/doe-fy2019.pdf page 383.
[32] https://www.whitehouse.gov/wp-content/uploads/2018/02/doe-fy2019.pdf p. 382.
[33] https://docs.house.gov/meetings/AP/AP00/20180516/108312/HRPT-115-HR-FY2019-EnergyandWater.pdf p. 88.
[34] https://www.whitehouse.gov/briefings-statements/statement-press-secretary-fuel-secure-power-facilities/
[35] https://www.documentcloud.org/documents/4491203-Grid-Memo.html
[36] https://www.documentcloud.org/documents/4491203-Grid-Memo.html

- All types of power plants are vulnerable to reliability and resilience threats. Coal plants are vulnerable to disruption or congestion in rail and barge deliveries of coal.[37] During recent droughts, coal and nuclear plants have been forced to reduce their output in peak summer demand periods due to cooling water constraints.[38] On page 20, DOE's memo quotes NERC's discussion of the impact of natural gas failures during the Polar Vortex event, while omitting the surrounding sections of NERC's report that discussed the equally large failures at coal plants. During the Polar Vortex, Bomb Cyclone, and ERCOT 2011 cold snap, equipment failures and not fuel supply issues caused most generator outages; these equipment failures occur regardless of fuel source.[39]
- Although the leaked memo warns that natural gas pipelines are vulnerable to cyber-attacks, it ignores the fact that all power plants (including coal and nuclear) and control rooms are similarly vulnerable to cyber threats.
- Nuclear plants are the least flexible of all major resource types and are unable to respond to grid frequency deviations.
- Coal plants are also inflexible, and systematically fail to accurately follow frequency regulation signals.[40] NERC has found that around 90% of conventional power plants fail to provide sustained response to stabilize frequency following a grid disturbance.[41]
- 99+% of customer outage-hours are caused by distribution and transmission system failures, not by generation failures or fuel delivery problems.
- As noted above, around 90% of military base power outages occur due to failures of power lines and other electricity distribution equipment on the military base. If the goal is to improve electric reliability and resilience at military bases, the solutions discussed earlier in my testimony would be far more effective than subsidizing unneeded coal and nuclear plants.
- Most customer outages are weather-driven, and weather-driven events impact distribution systems more than generation.
- Fuel security problems have historically caused fewer than 1 out of every 1.4 million hours of customer electricity outages.[42] Nearly all U.S. power markets have a large surplus of capacity; the generation reserve margin in PJM is currently over 32%, twice the region's target level.[43] PJM[44] and other grid operators have documented[45] that increasing reserve margins above 20% provides almost no incremental benefit to power system reliability. More fundamentally, when many power plants are facing economic pressures because electricity markets are oversupplied, subsidizing coal and nuclear plants will only exacerbate their challenges by sustaining over-supply and allowing

[37] https://www.ncac-usaee.org/resources/Documents/Presentations/2014/2014_12Heller.pdf
[38] https://www.eia.gov/todayinenergy/detail.php?id=7810
[39] https://www.aweablog.org/renewables-grid-market-based-solutions-support-reliability/
[40] https://ieeexplore.ieee.org/document/6815753/
[41] https://www.nerc.com/docs/pc/FRI_Report_10-30-12_Master_w-appendices.pdf
[42] https://rhg.com/research/the-real-electricity-reliability-crisis-doe-nopr/
[43] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_05252018_Final.pdf, page 7
[44] http://www.pjm.com/-/media/committees-groups/committees/pc/20171012/20171012-item-03a-2017-pjm-reserve-requirement-study.ashx, page 39
[45] https://gridprogress.files.wordpress.com/2018/05/customer-focused-resilience-final-050118.pdf, page 61

expensive, inefficient and inflexible old power plants to crowd out more efficient and low-cost producers that better contribute to grid reliability and resilience.

- Coal and nuclear plants have relatively poor "ride-through" capability, meaning they drop off-line when they encounter a small disturbance on the grid. Compared to new wind plants, it takes very little to shut down coal and nuclear plants, so they are not "resilient" on their own. These frequency and voltage disturbances are likely to be among the most disruptive consequences of a physical or cyber attack on the grid. Coal and nuclear plants are just as vulnerable to attack as other resources. If anything, renewable plants tend to be smaller, which reduces the impact of any failure. Regardless, generator-specific resilience has minimal impact on customers given the reliance on transmission and distribution to serve customers.
- Keeping the lights on following the loss of large fossil and nuclear power plants is a far larger challenge and expense for grid operators than the gradual and predictable changes in wind and solar output.[46]
- New generation tends to be much more reliable than the old generation that is retiring which has approximately 3 times the outage rates in PJM.[47]
- Contrary to the claim in the DOE memo that electric resilience is not being addressed, NERC has explained that its existing reliability standards and other requirements already address electric resilience.[48] The vast majority of the 150 comments filed in FERC's resilience docket AD18-7 offer extensive detail on how power system resilience is being addressed effectively today.

The administration's leaked memo also relies on flawed studies. For example, the National Energy Technology Laboratory study referenced on page 14 calls coal power "resilient" because it increased output during the Bomb Cyclone event relative to an arbitrary time period in December 2017. All that example shows is that during the December time period many coal power plants were not operating at full output because the grid operator was properly dispatching less costly natural gas-fired and wind generation, so the coal plants had a great deal of idle capacity available to increase output when demand and prices increased during the Bomb Cyclone.[49] The NETL findings do not indicate coal plants' resilience, but rather just their poor economics. Similarly, oil-fired power plants increased their output even more than coal plants during the Bomb Cyclone. This does not mean oil generators are resilient, only that they are also expensive. This is basic power sector "economic dispatch," used since the beginning of the industry and in all countries.[50]

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[46] https://www.aweablog.org/fact-check-winds-integration-costs-are-lower-than-those-for-other-energy-sources/

[47] https://www.pjm.com/-/media/committees-groups/committees/mc/20171026/20171026-item-03-2017-irm-study-presentation.ashx slide 7. Recently retired generation has a forced outage rate of 14.56 percent while newly added generation has a forced outage rate of 4.42 percent.

[48] https://www.nerc.com/comm/PC/Agenda%20Highlights%20and%20Minutes%202013/Draft_PC_Meeting_Presentations_March_6-7_2018_Jacksonville_FL.pdf, page 57

[49] http://sustainableferc.org/fossil-lab-misses-mark-in-cold-weather-resilience-report/

[50] http://www.pjm.com/-/media/library/reports-notices/weather-related/20180413-pjm-response-to-netl-report.ashx?la=en

The NETL study also understated the large contribution of renewable resources during the Bomb Cyclone. Even though wind energy output was well above average during the Bomb Cyclone event, NETL incorrectly claimed renewable output was low because NETL's analysis only compared output against the arbitrary December 2017 time period, when renewable output was also above average.[51]

The leaked memo also cites studies by IHS Markit that assert the economic value of coal and nuclear power in the PJM region. Several articles have challenged the validity and quality of these studies' analytic methods and claims.[52]

It is noteworthy that among the long list of resilience recommendations from the National Academies of Sciences, there is no recommendation to keep old coal and nuclear plants on line. The two issues simply have nothing to do with each other.

Finally, the Administration's memo asserts national security concerns regarding the continuing loss of aging coal and nuclear plants, but as noted above there are far better ways to support defense facility reliability and resilience than keeping old coal and nuclear plants in operation. The annual cost of DOE's proposed subsidies, using either ratepayer or taxpayer money, is estimated to be in the tens of billions of dollars per year.[53] Based on an estimated cost of $65 billion per year for the DOE proposal, that money could be used to instead:

- Increase grid resilience by installing over 300,000 miles of new electricity distribution lines each year, enough to cross the U.S. more than 150 times;[54] or
- Move around 100,000 miles of existing overhead distribution lines underground each year;[55] or
- Install over 200,000 MW of backup generators each year,[56] enough to cover the Defense Department's total electricity needs more than a dozen times over; or
- Make thousands of military facilities more energy efficient, reducing the electric load that must be served and protected when a grid or national emergency event occurs.

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[51] http://www.aweablog.org/wind-energy-perform-bomb-cyclone/

[52] https://www.aweablog.org/report-ignores-renewable-technology-advances/

[53] Last fall, DOE issued a Notice of Proposed Rulemaking (NOPR) to the Federal Energy Regulatory Commission that appears to be similar to DOE's latest proposal; but the latest proposal appears to apply nation-wide rather than to just the MISO, PJM, NYISO, and ISO-NE grid operators. The PJM Independent Market Monitor estimated that the NOPR would have cost PJM customers between $3 billion and $32 billion per year, with a middle case of $13 billion per year. Since PJM accounts for about 20% of U.S. electricity demand, a central estimate is that the latest proposal would cost around $65 billion per year. See https://www.rtoinsider.com/doe-nopr-pjm-market-monitor-cost-allocation-78830/, https://www.nytimes.com/2018/06/01/climate/trump-coal-nuclear-power.html

[54] https://www.eia.gov/todayinenergy/detail.php?id=7250

[55] *Id.*

[56] Based on a backup generator cost of $300/kW
https://www.acq.osd.mil/eie/Downloads/IE/Attachment%202%20-%20What%20does%20$1M%20in%20resilience%20buy%20me_v6.pdf

However, actual spending for military base electric resilience has remained flat. The budget for DOD's Energy Resilience and Conservation Investment Program has fallen from as high as $174 million in 2010 to $150 million today,[57] with no increases for inflation, and with a $150 million request for FY2019.[58] In FY2018, funding for only 7 energy resilience projects was requested (although the Senate did recommend spending an additional $15 million).[59] The FY2019 budget request also proposes cuts to assessments of military base resilience.[60]

VII. OE's modeling to support the bailout plan should be scrutinized carefully and should not divert resources from valuable OE work

A top OE priority currently is to spend two years on a continental multi-sector model. I am concerned that this model will be used to support the administration's misguided plan to bail out old uneconomic and unreliable generation sources and divert important resources and attention away from valuable OE work.

A model with so many variables can easily be adjusted to lead to certain answers. Every model is a "black box" to some extent, but this one will be murkier than most given its complexity and the confidentiality of many of the inputs. Most technical models earn credibility after extensive peer review of both input assumptions and internal mechanics. In the case of a model purporting to identify critical national energy assets and infrastructure, such review is likely to be complicated by assertions that the inputs and outputs are classified national security information that should not be aired for public or expert technical review.

It is not clear DOE will be able to gain access to the data it would need for such a model anyway. Utilities and RTOs have data on their system under confidentiality protections and they are not subject to FOIA. Utilities, RTOs and NERC run analyses and have detailed models of their own systems, and likely have as good a sense of the security-critical assets on their systems as DOE-OE may eventually develop with its emerging infrastructure model.

VIII. Conclusion

I appreciate the Subcommittee's interest in this important topic. There are some very valuable work streams in the Office of Electricity that can support reliability, resilience, efficiency, and the grid's evolution given changes in the resource mix and evolving threats. That work should be continued and expanded. At the same time, the President and DOE are undertaking a misguided program to fund the continued operation of old, uneconomic and unreliable power plants. It will be important for Congress to rigorously oversee the Department of Energy, and

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[57] https://www.acq.osd.mil/eie/IE/FEP_ECIP.html

[58] https://docs.house.gov/meetings/AS/AS03/20180418/108135/HHRG-115-AS03-Wstate-NiemeyerL-20180418.PDF, page 14

[59] https://www.congress.gov/115/crpt/srpt130/CRPT-115srpt130.pdf, page 10

[60] http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2019/budget_justification/pdfs/01_Operation_and_Maintenance/O_M_VOL_1_PART_1/Volume_I_Part_I.pdf, page 574

the Office of Electricity specifically, to ensure that important work gets done and taxpayer dollars are not wasted on ill-conceived programs.

By driving grid expansion and better utilization of the existing grid, DOE can help provide consumers with access to more affordable and reliable power.

Rob Gramlich

President, Grid Strategies LLC

Rob Gramlich has been working to drive grid modernization and expansion efforts since the mid-1990s. Through senior positions in government and the private sector, he has developed and led initiatives on renewable energy integration, market design, and transmission policy.

Rob oversaw transmission policy for the American Wind Energy Association from 2005 through 2016 as Senior Vice President for Government and Public Affairs, Interim CEO, and Policy Director. He was Economic Advisor to FERC Chairman Pat Wood III from 2001 to 2005, Senior Economist at PJM Interconnection in 1999 and 2000, Senior Associate at PG&E National Energy Group in 2000-2001, and an analyst at the FERC Office of Economic Policy, ICF Resources, the World Resources Institute, and the Lawrence Berkeley National Laboratory in the 1990s.

He has testified before the US Congress, US Federal Energy Regulatory Commission (FERC), and state regulatory commissions. He has served on advisory committees for the U.S. Department of Energy and the North American Energy Standards Board, on boards of a number of regional clean energy organizations, as Vice Chair of the Business Council for Sustainable Energy, and as Interim Executive Director of the Wind Energy Foundation.

Rob has received the following awards and recognition:

- Energy Systems Integration Group Award "for contributions to market design and transmission planning for improved system planning and operation." (2018)
- The Hill magazine: Top Lobbyist each year from 2011 through 2016.
- American Wind Energy Association: Technical Achievement Award "in recognition of significant contribution to articulating how wind can provide 20 percent of US electricity demand by 2030." (2008)
- US Federal Energy Regulatory Commission: Exemplar of Public Service Award "for a distinguished career in pursuit of the vision, mission, and values of the Federal Energy Regulatory Commission." (2005)

In the area of grid integration of clean energy, Rob has:

- Led the development for the wind industry of the 2008 20 Percent Wind by 2030 project with the Department of Energy and wrote the transmission chapter.
- Led negotiations for the wind industry on transmission interconnection standards (low voltage ride-through, reactive power, SCADA) that became FERC Order No. 661.

- Led wind industry negotiations in FERC Order 890 which lessened imbalance charges and created conditional firm transmission service.
- Led multiple coalitions in support of federal transmission policies.
- At FERC, played a key role in the creation of the Southwest Power Pool RTO, Midcontinent Independent System Operator, and the original market designs and structures of NYISO, CAISO, ISO-NE, PJM, SPP, and MISO.
- At PJM, served as principal market monitor of the PJM capacity market.
- Co-authored Green Power Superhighways report for AWEA and SEIA.
- Published articles on wind integration, wind markets and policy, economic incentives for environmental protection, power market regulation, and electricity market design.

Rob has a Master of Public Policy (MPP) degree from UC Berkeley and a BA with Honors in Economics from Colby College.

Chairman WEBER. Dr. Heppert, you're recognized for five minutes.

TESTIMONY OF DR. JOSEPH A. HEPPERT,
VICE PRESIDENT FOR RESEARCH,
TEXAS TECH UNIVERSITY

Dr. HEPPERT. Good morning, Chairman Weber, Chairman Smith, and Members of the Subcommittee. I'm Vice President for Research and Professor of Chemistry at Texas Tech University, and I'm pleased to address you today on behalf of Texas Tech University.

Texas Tech University's original mandate was to serve the educational needs of the citizens of West Texas, but its ambitions, as framed by its first President, have always been to make a mark in education, scholarship, and innovation for the nation and the world.

Today, Texas Tech University—or "Tech" as it's often referred to—ranks among the major public research universities in the United States. As many of you know from working with research universities in your states and districts, these institutions play a critical innovative role in defining the future of energy grid research.

Both natural hazards and actions by our adversaries can pose significant threats to our grid. In—the 2017 hurricane season was a harrowing reminder of the intense suffering and economic loss that natural events can inflict on regional scales. Communities in Texas, Florida, and Puerto Rico were—and in some cases continue to be—devastated in the aftermath of these storms. Based on modern scientific models of future weather events, the world can expect more frequent and more intense disruptions of this nature.

At the same time, there's a growing consensus that future conflicts among major military and economic adversaries may involve preliminary skirmishes in cyberspace with grid infrastructure as a prime target. Indeed, some recent cases provide indications that both state and nonstate actors have already targeted and demonstrated an ability to threaten our grid. On top of this, any grid of tomorrow must be developed with the assumption that the market for renewable energy generation will only continue to grow and, in turn, provide a more decentralized and therefore resilient system.

In light of these challenges and with generous support of the State of Texas, Department of Energy, and partners in industry and at the national laboratories, Texas Tech has been working hard to address a central question: How can we make the U.S. energy grid more secure, reliant, robust, and, perhaps most importantly, resilient when under threat?

Through the pioneering work of faculty at Texas Tech, we're providing answers. Dr. BeiBei Ren in Texas Tech University's Whitaker College of Engineering has developed a novel architecture for smart grids that allows an array of diverse power sources to interface with the grid. Her research has overcome a major hurdle to enabling reliable, resilient, and affordable grid integration of renewables with the real-world applicability of helping to rebuild Puerto Rico's communication infrastructure post-Hurricane Maria.

Dr. Stephen Bayne, a senior faculty member in the Whitaker College of Engineering's Department of Electrical Engineering, is a distinguished power grid researcher. Dr. Bayne's group continues to develop techniques that enable grid integration when incorporating renewable energy sources and have placed a number of instruments across Texas to monitor grids in near real time. This research, when coupled with innovative models to determine and predict the performance of systems relying on distributed generation such as wind, is critical to a more resilient and reliable grid.

In 2015, the State of Texas provided $13 million for Texas Tech University and several partners to construct GLEAMM. When fully operational later this year, the Global Laboratory for Energy Asset Management and Manufacturing will provide a world-class distributed generation microgrid and unique platform for field-testing certification and optimization of renewables and grid systems, new hardware and software solutions for managing grid function, and cybersecurity of grid systems. This work would not be possible without the support of Secretary Rick Perry. His vision as Governor of the State of Texas was critical to making this facility possible.

The innovative team of researchers across Texas Tech University is committed to a research vision that enables the electric grid of the future. Over the next four years, we intend to invest a minimum of $8 million in research into cybersecurity and energy grid resiliency to enable the creation of a sustainable and diverse energy economy. We're confident this investment will help the nation attain its goals in energy security, traditional and alternative energy utilization, and a 21st-century energy grid.

I'm proud to have the opportunity to share Texas Tech's capabilities, our expansive vision for the future, and serve as a resource for this subcommittee. I look forward to answering your questions. Thank you for this invitation, and, go Tech.

[The prepared statement of Dr. Heppert follows:]

TEXAS TECH UNIVERSITY
Office *of the* Vice President
for Research

Good morning Chairman Weber, Ranking Member Veasey, Chairman Smith, and Ranking Member Johnson, and members of the Subcommittee. I am the Vice President for Research and Professor of Chemistry at Texas Tech University. I am pleased to address you today on behalf of the Texas Tech University System.

The Texas Tech University System's original mandate was to serve the educational needs of the citizens of West Texas, but its ambitions, as framed by its first president, have always been to make a mark in education, scholarship, and innovation for the nation and the world.

Today, the Texas Tech University System – or just "Tech", as it's often referred to – boasts a student population of 37,000 and is the largest public research university in the western two-thirds of the State of Texas. Tech has been recognized as a Tier One public research institution, the highest classification offered by the Carnegie Foundation. Lubbock, home to our main campus, is one of the fastest growing communities in Texas. Reflecting the changing demographics of Texas and the nation, Tech has recently been recognized for attaining the threshold required for Hispanic-serving institution status with over one-quarter of our undergraduate enrollment reflecting Hispanic heritage. Tech truly embodies the promise of the future of public higher education in the nation, and we aspire to lead in the quality of our educational experience; the prominence and impact of our research, scholarship, and creative activity; and our service and engagement in the community, the United States, and the world. As many of you know from working with research universities in your states and districts, these institutions play a critical and innovative role in defining the future of energy grid research.

Both natural hazards and actions by our adversaries can pose significant threats to our grid. The 2017 hurricane season was a harrowing reminder of the intense suffering and economic loss that natural events can inflict on regional scales. Communities in Texas, Florida, and Puerto Rico were – and in some cases continue to be – devastated in the aftermath of these storms. Based on modern scientific models of future weather events, the world can expect more frequent and more intense disruptions of this nature. At the same time, there is a growing consensus that future conflicts among major military and economic adversaries may involve preliminary skirmishes in cyberspace, with grid infrastructure as a prime target. Indeed, some recent cases provide indications that both state and non-state actors have already targeted and demonstrated an ability to threaten the grid. On top of this, any grid of tomorrow must be developed with the assumption that the market for renewable energy generation will only continue to grow and, in turn, provide a more decentralized – and therefore resilient – system.

In light of these challenges, and with generous support from the State of Texas, Department of Energy, and partners in industry and at the National Laboratories, Tech has been hard at work addressing a central question – how we can make the U.S. energy grid more secure, reliable, robust, and, perhaps most importantly, resilient when under threat?

TEXAS TECH UNIVERSITY
Office *of the* Vice President
for Research

Through the pioneering work of faculty at Tech, we are providing answers. This morning, I am pleased to present the range of collaborations that Tech has developed to create a lasting national impact in ensuring the development of communities reflecting more resiliency and efficiency in energy grid technology.

In 2015, the State of Texas provided $13 million through the State of Texas's Emerging Technology Fund to create the Texas Tech-led Global Laboratory for Energy Asset Management and Manufacturing – also known as GLEAMM. GLEAMM is a world class distributed generation micro-grid located at the Reese Technology campus (formerly Reese Airforce Base). As part of the Emerging Technology Fund award, TTU collaborated in the creation of Group NIRE, a 501(c)(3) corporation, whose mission is to partner with industry on the creation and certification of new grid technologies. Mark Harral, CEO of Group NIRE, is partnering with X-Fab Corporation, a regional silicon device manufacturer, and National Instruments Corporation of Austin, Texas on the project. Together, Tech and Group NIRE are developing $30 million in facilities at the Reese Technology Center site, including a new research-grade micro-grid and Phasor Measurement Unit (PMU). These new facilities will become operational later this year. GLEAMM is being constructed under the direction of Dr. Annette Sobel and will optimize conditions for the integration of solar and wind technology into grid systems, develop new hardware and software solutions for managing grid function, and enhance the cybersecurity of grid systems. This important work would not be possible without the support of Secretary Rick Perry. His vision as the Governor of the State of Texas was critical to making this facility possible.

Dr. BeiBei Ren is a faculty researcher in TTU's Whitaker College of Engineering studying micro-grid control and energy grid integration. In collaboration with Syndem, Inc., Dr. Ren is developing synchronized and democratized architectures for next-generation smart grids. This novel architecture will allow diverse power suppliers to interface with the grid as virtual synchronous machines, playing an active role in the regulation of system frequency and voltage. Dr. Ren's micro-grid control technology received the 2017 TechConnect National Innovation award. Dr. Ren's group is collaborating with Syndem, Inc., Group NIRE, Inc., the Puerto Rico Telecommunications Regulatory Board, the National Renewable Energy Laboratory, the Pacific Northwest National Laboratory, and the Oak Ridge National Laboratory to develop photovoltaic storage inverters to generate reliable, resilient, and affordable grid integration to rebuild Puerto Rico's infrastructure following damage from Hurricane Maria.

Dr. Stephen Bayne, a senior faculty member in the Whitaker College of Engineering's Department of Electrical Engineering, has a long history with power grid research. Dr. Bayne worked with Alstom, Inc. (now GE) to model wind turbines under steady state and transient conditions. His group developed advanced wind turbine control algorithms to minimize overvoltage and overcurrent conditions and created a battery model for a 1MW/1MWh li-Ion battery connected to the distribution grid at Reese Technology Center. Dr. Bayne has studied a range of control techniques for grid integration when incorporating high penetration of renewable energy. Dr. Bayne's group has deployed a number of PMUs across Texas to monitor and potentially control energy grid systems in near real-time. Dr. Bayne's group has also developed model micro-grids to determine the performance of systems relying on distributed generation and loads.

TEXAS TECH UNIVERSITY
Office *of the* Vice President
for Research

This research, when coupled with innovative models that determine and predict the performance of systems relying on distributed generation such as wind, is critical to a more resilient and reliable grid.

Tech is a leading institution in grid research, but it also focuses heavily on advancing research in renewable energy technologies. Since the 1960s, Texas Tech University has been a national leader in wind damage research, collaborating to create many of the standard storm-resilient building codes in use throughout the U.S. today. This expertise in wind research led Tech's National Wind Institute (NWI) into collaborations with wind energy researchers in the early 2000s. In cooperation with Sandia National Laboratory, NWI helped establish a wind turbine test facility on our Reese Technology Center campus that boasts three test windmills just outside of Lubbock. This facility is fully instrumented to support the analysis of wind patterns and lightning events across the turbine farm. Under the direction of Dr. Michael Giesselmann, a pulsed power researcher, Tech has capitalized on this experience to collaborate with Pantex, Inc. in Amarillo, Texas to optimize the unit commitment of their wind farm. Dr. Giesselmann is collaborating on the development of a model to take wind forecast and other load forecast factors and to use artificial intelligence (AI) to derive locational marginal pricing information (LMP) with training datasets using historic data. This will enable operators to predict when it is not economically feasible (negative LMP) to feed wind power into the grid.

The innovative team of researchers across Tech is committed to a research vision that enables an electric grid of the future. Over the next four years, we intend to invest a minimum of $8 million dollars in research into cybersecurity and energy grid resiliency to enable the creation of a sustainable and diverse energy economy. We are confident this investment will help the nation attain its goals in energy security, traditional and alternative energy utilization, and a 21st century energy grid.

I am proud to have this opportunity to share Texas Tech University's capabilities, our expansive vision for the future, and serve as a resource to the Subcommittee. I look forward to answering your questions. Thank you for this invitation, and "Go Tech!"

TEXAS TECH UNIVERSITY
Office *of the* Vice President
for Research

Joseph A. Heppert, Ph.D.

Vice President for Research

Professor of Chemistry

Texas Tech University

Dr. Heppert is currently Vice President for Research at Texas Tech University. Previously, he served as Associate Vice Chancellor for Research at the University of Kansas (KU). He chaired the KU Chemistry Department from 2005-2009 and was the founding director of the University's Center for Science Education from 2001-2009. He is a Fellow of the American Chemical Society, and currently serves as chair of the American Chemical Society's Committee on Budget and Finance.

Dr. Heppert's initial research focused on organo transition metal chemistry. This research resulted in the isolation and characterization of the first class of air stable terminal transition metal carbide compounds. Dr. Heppert has also been active in projects to improve science teaching and science teacher preparation. He is past chair of the American Chemical Society's Committee on Education. In this role he testified before the U.S. House of Representatives' Committee on Science and the National Science Board on science education policy issues.

Dr. Heppert received a B.S. in Chemistry from San Jose State University in 1978, where he participated in heavy elements research at the Lawrence Livermore National Laboratory. He was awarded a Ph.D. in Inorganic Chemistry from the University of Wisconsin-Madison in 1982, studying under Donald Ganies. He completed postdoctoral training at Indiana University under the direction of Dr. Malcolm Chisholm. He joined the chemistry faculty at KU in 1985 and moved to Texas Tech University in 2017.

Chairman WEBER. I'll leave that alone.

So they've called votes, so we're going to recess, and we will reconvene immediately following the last vote.

[Recess.]

Chairman WEBER. This hearing is now reconvened. I thank the witnesses for their testimony. The Chair recognizes himself for five minutes of questioning.

Mr. Walker, in your testimony, you stress that OE's priorities are the development of grid modeling capabilities, megawatt-scale grid storage, and the Grid Modernization Initiative. As the smallest of the applied energy offices at DOE, how are you able to accomplish your research and development goals with a tight budget, number one? I guess, essentially, how does the OE do more with less? What do you say?

Mr. WALKER. Thank you, Congressman, for the question. The focus with OE is definitely on those three things, as well as sensing technology. And how we accomplish our mission is through the hard work of the people within OE and CESER working in concert with the other applied sciences at DOE, so among fossil energy, nuclear energy, and the energy efficiency, primarily relying on the platform of the GMI, the GMLC, and that's in fact why we expanded the charter to include those other applied sciences to be able to leverage and ensure that the investments we make are the best across the entire department and to leverage the resources, you know, equally from a national security perspective.

Chairman WEBER. So prioritize. The programs within OE are squarely within the applied energy mission of the Department, and OE research goals are closely tied to the needs of the energy industry. The Department's fiscal year 2019 budget request places an importance on federal funding only toward early-stage research programs—only towards early-stage research programs. What steps have you taken to ensure responsible stewardship of those taxpayer dollars by funding only the R&D that cannot be performed by the energy industry?

Mr. WALKER. So at OE we focus very much on early-stage research, utilizing our capabilities both on the CESER side, as well as OE, to identify where are the cutting-edge technologies that will not be, by virtue of the cost and, more importantly, the intellectual capability that is realized through our national labs. So we identify, using a risk-based approach, how to best invest that money.

Chairman WEBER. I thank you. Dr. Heppert, this question is for you. In your testimony, you explain how Texas Tech University partners with both Sandia National Lab and the private industry to conduct research. What is the difference between research conducted at the GLEAMM facility and the research conducted at the Sandia SWiFT site? And should there be more coordination between the national labs and academia on grid challenges like those identified in the GMI?

Dr. HEPPERT. Sure. I think there's a degree of commonality in terms of some of the research. The SWiFT site really has been a testbed for understanding windfarms and the fundamental impact of atmospherics and of fluid flow through windfarms. We've got highly instrumented systems there with radar that can help us model that and help us understand the impact of environmental

circumstances on the performance of those systems. So it's really in part about predictive modeling and understanding how to optimize the configuration and structure of future windfarms, okay?

The GLEAMM system is really going to be a testbed that will allow us to actually connect to some of these existing resources in addition to some resources that are held in the private sector nearby of both wind power, solar power, and battery capabilities. The focus there is really going to be on being able to testbed new technologies, both software and hardware technologies, to allow us to understand how to better integrate those and more seamlessly integrate those systems; model in real time, be able to model conditions that are going to lead to grid—potentially to grid failure; and understand, using artificial intelligence strategies, how we can more effectively integrate these; and also how we can improve and enhance the economics of utilizing energy from these systems as well.

So I would say on the one side we're talking about looking more at the fundamentals of wind, and we're very pleased on that side that we'll be helping to cohost the wind blade design conference that Sandia has held for many years at Sandia this year in Lubbock. But on the other side, we're looking more at how we truly integrate these other technologies effectively. And it'll be a great testbed for being able to take, as I said, both AI technology and new power grid technologies hardware and integrate them into a system.

Chairman WEBER. Thank you for that. Can you get the dates of that conference to our staff here?

Dr. HEPPERT. I'll be happy to do that.

Chairman WEBER. Yes, okay. Thank you.

At this time the Chair recognizes Mr. Takano for five minutes.

Mr. TAKANO. Thank you, Mr. Chairman.

Dr. Heppert and Dr. Sarrao, the Trump Administration has proposed a 37 percent cut in fiscal year 2019 for the Office of Electricity, or OE, which stewards the largest portion of our federal investments in grid research. Within OE, the budget proposes a number of steep cuts to important research, including a 74 percent cut to smart grid research, a 67 percent cut to clean energy transmission and reliability, and an 81 percent cut to energy storage research and development.

I just want to know from all of you, what role do you think energy storage and the development of battery storage can play when it comes to distributing wind and solar, as well as grid resilience?

Dr. HEPPERT. Well, I would say that the magnitude of the cuts you're referring to are quite concerning. We're dealing with technologies here that are in—really in development. The challenges we're facing in terms of the scale of renewables that have to be integrated into the grid has changed dramatically over the last five years. The challenges associated with both creating a resilient system, understanding how to use battery technology effectively in order to create a stable microgrid system, a regional grid system, and doing the kind of effective modeling on how to optimize those systems, those are all landscapes that are changing. And in addition to that you'll recognize what we—a number of us talked about with regard to the security issues, which is a constantly changing landscape as well.

So I think federal funding is critically important, sustained federal funding is critically important for us to be able to take advantage and leverage some of the model systems that we developed across the country, including what's going on within the SWiFT and GLEAMM programs at my institution but also other institutions.

So as far as impact is concerned on our programs, I would see, you know, in any one year we're in the vicinity of $2.5 million worth of funding that could potentially be impacted by some of those cuts, and that—again, that would make it very difficult for us to leverage the investment that the federal government, the national labs, and the State of Texas have already made in some of the unique model systems we have on our campus.

Mr. SARRAO. Yes, thank you for the question. As you know, certainly a decrease in budget would create challenges. I think from a Los Alamos perspective, one of our goals is to use capabilities that derive from our broader national security mission focused on challenges of grid modeling so that we can diversify our efforts in that regard. Certainly, our focus on early-stage research, as well as partnerships like the GMLC enable—cause us to be as effective as we can be.

And then to your question about energy storage, I think thinking both about fundamental, for example, materials and chemistry research and energy storage and how you think about that in the broader context of the electricity grid is something that our grid modeling efforts help enable so that we find the right challenges to focus on to address the problems in an environment that's potentially fiscally constrained.

Mr. TAKANO. Yes. So, Mr. Gramlich, in your testimony you note that the recent DOE grid reliability staff report found that, quote, "Increased deployment of solar and wind does and will not negatively impact the operation of the grid." Mr. Gramlich, what role do you think energy storage and development of battery storage can play when it comes to distributing wind and solar, as well as grid resilience?

Mr. GRAMLICH. Thank you for the question. I think energy storage can provide many services to the grid, to customers, specifically to distribution systems, transmission systems, and it provides services that are typically considered generation services, so it's really the only technology that sort of provides almost some of everything. It will be, I think, important when we get to very high renewable energy futures. You can integrate a whole lot of wind and solar I think without a huge amount of storage now currently in most regional grids, but certainly island systems and other areas require more balancing. And, over time, as penetrations of renewable variable resources grow, storage will become more and more important.

Mr. TAKANO. Well, great. Thank you. My time is up, Mr. Chairman. I can yield back, please.

Chairman WEBER. Okay. The Chair now recognizes the gentleman from Alabama, Mr. Palmer, for five minutes.

Mr. PALMER. Thank you, Mr. Chairman.

Mr. Walker, can you speak to the concerns that the more connected the grid becomes, the more vulnerable it becomes to cyber attacks similar to, you know, what happened in Ireland last year?

Mr. WALKER. The—as Dan Coats, our Director of National Intelligence, noted, the—we are recognizing more frequent and more sophisticated cyber threats. There is no question that the grid is vulnerable to cyber threats, whether they're isolated or whether they're fully integrated. What is clear, as we introduce cyber-enabled technologies through the Internet of Things and the advancements of things like smart grids, we introduce more and more devices on the system that have the capability of being penetrated through cyber, so it is extremely important that, as we develop these newer technologies and as we integrate additional technology on the system, that we do it with a cybersecurity focus.

We have just recently issued a funding opportunity for $25 million back into the oil and natural gas as well as electric sector to look at the architecture and the design of cyber-enabled devices to—in order to stave off the risk as we move forward and capitalize on the existing underlying physics of the system.

Mr. PALMER. Well, I understand we want to protect our systems from being hacked, but also, I think we've had some experiences, particularly in the last few years, with hurricanes and in the last couple of decades with Katrina and others where we lost whole sections of the power grid, and one of my concerns is if we had a major cyber attack or an EMP attack is whether or not you have redundant systems. And I don't mean just having equipment to replace equipment that's been fried basically or whether or not you're—how quickly you're able to shift from a technology-controlled system to a manual system, whether or not you have trained employees that—I see you're nodding your head there.

Those are the concerns that I have is in terms of preparation is how long would it take and, depending on the time of year, how serious restoring power would become. And so that—Mr. Chairman, I think that's part of what we've got to figure out here is in the event that we have an attack like that, that, you know, in cases with the storms, it takes anywhere from a day to a week. You—that's tolerable. But if you get into a situation where you have a massive loss of equipment and you can't shift to a manual system, then you really got a problem. Our—is that some of the things that——

Mr. WALKER. That's absolutely——

Mr. PALMER. —I'm sure you're thinking through that.

Mr. WALKER. That's absolutely what we are 100 percent focused on. So under the FAST Act, there was a requirement for the Secretary to identify defense-critical electric infrastructure, and we continue to evolve that list of critical infrastructure with an understanding of what the impact is across the 16 critical infrastructure sectors throughout the United States. And we are developing within OE operational strategies that are—we're executing on some of those now to better ensure that when we do have those widespread events, whether it be cyber or hurricane, that we have capability to restore the system, whether that be—and that's one of the focuses of having a fuel-secure generation source. When we have that, we don't have to rely on the supply chains and the risks associated with supply chains that might get realized during something like a cyber event or a hurricane where there's destruction from, you know, the port all the way to any facility.

Mr. PALMER. Maybe Mr. Gramlich and Mr. Heppert could address this, but when you're talking about a massive loss of the grid and you look at it in the context of what—what's the first thing we do when we have a major storm? We go in with food and water and medicine, that sort of thing. And a massive loss of the grid, that will be the number one thing because most people depend on the grocery store for their food and sustenance, things like that. So it's going to become absolutely critical that we either have redundant systems or the ability to shift to a manual system. And I'll let the gentlemen respond to that, Mr. Chairman.

Mr. GRAMLICH. I think you're absolutely right, Congressman, that preparing for that situation in advance, low probability as it may be, is absolutely something that needs to be done. Personally, I think the National Academies of Sciences' report recently was strong, had good recommendations in that area, so I would commend that for more information.

Dr. HEPPERT. I'd come back again to the concept that having both diverse grids and grids that have survivability at the local level where you can go down from a macroscopic grid to a microgrid, which will still operate and where you can bring up portions of that grid rapidly as the technology becomes repaired without risking bringing down the system again as a result of the initial insult is something that's really critical. That's—I think that's part of the reason that the kind of modeling we've been describing and the kind of research that we're promoting is really important for the future.

Mr. PALMER. Mr. Chairman, if I may, if you'll indulge me just for a moment here, I worked for a couple of engineering companies before running a think tank, and unless things have changed dramatically in the last 30 years, we have a patchwork grid. It's not a uniform grid. And in some cases that could be helpful, but in other cases then a massive loss. Again, I want to emphasize—and to your point, it's a low probability, but we need to be prepared. A low-probability event could have absolutely catastrophic and deadly consequences, so I really think that we need to be prepared for that. We need to recognize the fact that it is a diverse grid, it's a patchwork, and that we have some ability to address that in a relatively short amount of time.

So with that—and you can comment on that as you will, but, Mr. Chairman, thank you for indulging me, and I yield back.

Chairman WEBER. Thank you.

Mr. Tonko, you're now recognized for five minutes.

Mr. TONKO. Thank you, Mr. Chair, and thank you to our witnesses for being here today. Secretary Walker, it's good to see you again. Members of this committee may not know it, but Secretary Walker and I went through energy deregulation in New York State together. And I think it was a bold move. Our electric markets—electricity markets may not be perfect, but they have blind spots. And I think Congress and States and grid operators and regulators can all work together to address some of those market failures.

But in 2018 the toothpaste is out of the tube and drastic and unnecessary market interventions under the false pretense of an emergency to bail out uncompetitive generators like the one being discussed by the Administration I think are unacceptable. Mr. Sec-

retary, I will not ask you to respond to that, but I hope you will carry that message back to DOE.

However, I do want to ask you about the future of Puerto Rico's grid. As we enter hurricane season, I'm concerned about the fragility, the lack of resilience of that system. Can you give us a sense of some of the recommendations and work that has been done to strengthen Puerto Rico's grid for the long term?

Mr. WALKER. Sure. We have been working with Puerto Rico to develop a sophisticated modeling system that enables them to better operate their grid, and we've been working with the technical advisory committee that was established by PREPA's board to accomplish that. That model will also help identify the relaying setting changes that need to occur in order to better optimize the grid so that they don't sustain the blackouts that they've recently seen over the last year or two.

That being said, with the work that had—has been done from the emergency restoration component, you know, equipment was put back in place consistent with the north—you know, the standards—NAS standards, so, you know, the lack of O&M that was done on the system in one sense has been cured because the weak poles and the weak guying on the transmission system has been replaced. They are continuing and still working on one of the major transmission lines that goes through the north-south corridor. We are still there. DOE is providing technical assistance where we can for, you know, any of the technical components on the system, and we're still continuing to work with FEMA.

The PREPA is continuing to identify some of the strategies that they will employ for, you know, any events that will be realized, and, you know, one of the key components is we still have a—you know, a significant number of federal resources down on the island, including the generators, which were supplied for the critical infrastructure, the ones that were referred to Congressman Palmer. You know, we recognize that—and after the—the after-action reports that we've, you know, started to look at with PREPA and FEMA highlight that, you know, the 2,000-plus generators that are down there represent those critical infrastructure that we really need to make sure that we've got, you know, the microgrid capabilities, distributed energy resources so that when they do realize an event, it has less real impact on the safety and health of the people in Puerto Rico.

Mr. TONKO. Thank you. And, Mr. Gramlich, I would like to get your thoughts on this. Americans in Puerto Rico are reeling from the most devastating blackout in our nation's history. And obviously, Puerto Rico had unique challenges, but it is my understanding that many of its greatest grid vulnerabilities were damaged transmission and distribution systems, which is the cause of most disruptions in our continental United States. So Puerto Rico could be a testbed and model for grid innovation. Do you have ideas about how Puerto Rico can rebuild to have a stronger, more modernized grid?

Mr. GRAMLICH. Sure, Congressman. I have not spent much time researching Puerto Rico, but, generally, we do have a lot of technologies and options that are available to any system that may be rebuilding its grid. And in fact, our mainland transmission grid is

aging, and so we have opportunities to improve the technology there as well.

One key area that DOE and OE specifically support is the development of microgrids or backup generation, so when we're talking about national security or military bases or others—or critical uses or hospitals or police stations or other critical needs, recognizing there are still tremendous efficiencies of the large grid and large regional markets and all of that, but there are also thousands of entry points and risks on such a system. So when you're focusing on the end-use customer and their critical reliability needs that may exist, those ability to have backup generation or islanding capability that DOE can help and help bring down the cost for will be very important.

Mr. TONKO. Yes, it seems as though, in response to their need as an island, as a people, we can come up with a nice innovative response that will also serve as a template for what can be done across the continental United States. So with that, Dr. Heppert, I don't know if you wanted to say something, but I'm out of time, so—but if the Chair would allow for you to comment?

Dr. HEPPERT. Sure.

Mr. TONKO. With that, I would yield back.

Dr. HEPPERT. I just wanted to point out that one of our faculty members, Dr. Ren, is involved in a collaboration with Puerto Rico telecom, which involves a number of national laboratories, Pacific Northwest National Lab, Oak Ridge, as well as NREL, to implement some innovative new technology for democratizing their telecommunications grid and really bringing it back. So I think this has been a great example of how that partnership that the omnibus bill talks about between the private sector, universities, and national laboratories can really help to have an impact in real-time on these kinds of situations.

Mr. WALKER. Chairman, if I might address Congressman Tonko's question?

Chairman WEBER. Go ahead. He needs all the help he can get.

Mr. WALKER. Congressman, this—there are some very specific items that we are working with the labs on putting into Puerto Rico that are cutting-edge that would—we're basically looking to accelerate the commercialization of them and therefore utilization on the mainland by putting them in Puerto Rico, so things like our darknet, which is the use of the black fiber and the optical ground wire, which is on their transmission system is one idea. But using correlation through this high-fidelity sensing capability to enable optimization of their grid is another. That will be utilized in conjunction with the development of sophisticated microgrids that have the capability to expand and contract similar to some work that's being done at the Electric Power Board in Chattanooga with Oak Ridge National Lab, so there are a number of very specific things that we think Puerto Rico is uniquely poised to be able to integrate.

We've been working—I've been working with Walt Higgins, who's CEO, and we've been working—I've been working—my team's been working with HUD to help to find the guidance document with the supplemental funding that Congress provided all to ensure that,

you know, these type of technologies, the microgrids, the DERs, really do get in.

And one of the things that, Congressman, is very interesting and you're very familiar with, the Greenbank, one of the things we've talked about is actually a critical infrastructure bank in Puerto Rico and the possibility of that to enable those 2,000-plus locations that we previously identified through the installation of generation to come up with unique ways to basically island themselves and provide the capabilities for public health and safety that they do.

Mr. TONKO. Well, thank you for that info. I think it also speaks to the wisdom of not cutting research and innovation investments like ARPA–E and all. We are on the cutting-edge, we're an innovation economy, and we don't go backward, we need to go forward, so I would just say those investments are critical to be able to have those responses you just outlined.

With that, Mr. Chair, I yield back.

Chairman WEBER. The Chair now recognizes the gentleman from Virginia, Mr. Beyer, for five minutes.

Mr. BEYER. Mr. Chairman, thank you very much. And thank all of you for being with us this afternoon.

Secretary Walker, you previously stated on February 20 of this year, and I quote, "We would never use a 202 to stave off an economic issue. That's not what it's for." And now, FirstEnergy Solutions has recently asked the Department to use 202 to stave off an economic issue. Does that imply or do we understand that you won't use a 202 for them?

Mr. WALKER. The 202 application from FirstEnergy is being reviewed by my department as we speak.

Mr. BEYER. Great. Well, thank you. I'm hoping that your earlier strong opinion will still prevail.

You know, the draft grid memo was circulated before the National Security Council last Friday, and it's widely understood that this draft came from the Department intended to fulfill the President's June 1 directive to intervene in planned plant closures, but there's been an awful lot of pushback from people who are grid operators and grid experts. Specifically, the CEO of Exelon, the largest nuclear generator in the United States, said the retirement of coal and nuclear plants do not constitute a great emergency that warrants urgent intervention from the federal government.

Secretary Walker, the President of Electric—Electricity Consumers Resource Council in a study say—the large industrial electricity users say the latest DOE proposal would, quote, "devastate U.S. manufacturing." Have you calculated the costs on American businesses, specifically, American manufacturing?

Mr. WALKER. I have not.

Mr. BEYER. The previous 403 proposal, which was rejected by FERC because it was unsubstantiated, they said it was going to cost—increase consumer costs by $8 billion annually from PJM alone. Now, the new plan nationalized the 403 proposal, so I would expect that that $8 billion is going to go up very significantly. Again, in putting together this draft plan, have you estimated what this will cost the U.S. taxpayer?

Mr. WALKER. I have not.

Mr. BEYER. I have to give you wonderful credit for being able to answer these things very tightly. I would suggest, though, as a member of this committee, that moving forward with this new proposal, if it's going to devastate U.S. manufacturing, if it's going to add way more than $8 billion to the electricity cost of our American consumer, this is something that you and Secretary Perry and others should look very seriously at and should have numbers available for. I think it's within purview of—as a member of this committee to ask you to go back and do the elementary research and report back to the Committee on those two things, please.

And with that, Mr. Chairman, I would like to submit for the record a letter I led with 36 of my colleagues asking that Secretary Perry and the Trump Administration cease the false narrative that bailing out uneconomic energy sources in competitive markets is needed for electrical grid resilience and to stop the attempts to use emergency authorities to intervene in planned power plant retirements.

And I'd like to make three official points on the inappropriate use of emergency authorities that——

Chairman WEBER. Let me——

Mr. BEYER. —bail out planned power plant——

Chairman WEBER. Let me say without objection.

Mr. BEYER. Oh, thank you very much, Mr. Chair.

[The information appears in Appendix II]

Mr. BEYER. Number one, unlike these plant retirements in the PJM grid, we have a legitimate grid crisis in Puerto Rico. Thank you for addressing it, but we still have thousands of residents without power. The President himself has still not acknowledged the death toll, which we now understand to be higher than those lost on 9/11. This is his Katrina.

Number two, this bailout plan does not actually help coal country. This is a short-term talking point that does nothing to create good-paying jobs, resilient jobs for the families in Appalachian. We need to work together with these resilient, industrious, great families to create good-paying jobs that will endure.

And number three, the bailout plan ignores all the experts. Instead of listening to those in the universe of the world of energy grids and despite knowing what this would cost the American public, the Trump Administration is still moving ahead perhaps unfortunately likely because someone contributed to the campaign, and this is not how our democracy is supposed to work.

Mr. Chairman, I yield back.

Chairman WEBER. I thank the gentleman.

And we now recognize Dr. Foster from Illinois for five minutes.

Mr. FOSTER. Thank you, Mr. Chairman, and thank you to our witnesses.

Maybe I'd like to switch over to some sort of high-level direction that you need from Congress and the American people to think about your specifications for what you want the grid to accomplish in terms of reliability because there are—you know, people can be concerned about outages that are temporary, outages that—the tail risk of having an outage of six months or longer that can happen in some disaster scenarios. Insurance against the tail risk cost money, and there is a trade-off that, you know, everyone in life and

every one in business faces as to how much we're willing to spend to reduce tail risk, you know, how much spare inventory of different components we need to have on hand, things like that. And so do you feel that you have adequate high-level guidance from Congress and the American people about what the specs you're shooting for or do you think we need a wider discussion of that and related issues?

Mr. WALKER. Congressman, I'll answer the question from DOE's perspective. The DOE is one of three organizations that fundamentally analyzes the day-to-day operation of the electric grid. FERC is the other one, NERC is the other one, and each of us has different lenses by which we look at the system. FERC looks at it from a market base, NERC from a reliability perspective, and DOE looks at it from a national security perspective.

So from a national security perspective, the day-to-day reliability is not really something that we take a look at. Obviously, it's important. We contribute to it. We make R&D investments where it makes sense, but we also look at those investments from how they can be utilized from a national security standpoint. We recognize, particularly given the recent evolution of the grid, particularly its interdependence mostly on gas pipelines, that we have now reached a point where—different than 20 or 30 years ago where if I lose the wrong gas pipeline, I can lose tens of thousands of megawatts of generation simultaneously, and that simultaneous loss of all those generators can then have deleterious effects through, you know, cascading frequency loss, as you well know as a physicist. And there are real risks in the system as a result of it.

And, unfortunately, when we built these systems, built the gas pipelines, oil pipelines, the electric transmission system, things like cybersecurity didn't even exist, and the word domestic terrorism was probably not even coined yet. But today, we deal with very significant risk every day. And why—while some may say it's a low probability, we deal with tens of thousands of cyber intrusions on a daily basis. It's just a matter of time before the sophistication level increases and those penetrations become real.

We've seen this happen. We all watched the Ukraine event. So we can pretend that it doesn't exist, but we have hard evidence through actual realization of things like Ukraine that these capabilities exist and they're being utilized. And we spend our time focused on strategies that enable us to survive those type of events and avoid them.

Mr. FOSTER. Other comments?

Mr. GRAMLICH. Sure, Congressman. There is the North American Electric Reliability Corporation (NERC) that is in charge of reliability under the ERO provisions of the Energy Policy Act of 2005. I think that organization and the institutions around reliability need to be—remain in place. They are doing a good job. FERC overseas the markets and transmission system. Their role needs to be respected. I think what we're seeing with this presidential directive is, under the guise of national security, a nationalization of the electric system, which would be extremely damaging for the investment—the private investment that the industry currently relies on for all of the reliability and efficiencies that we get out of this power system.

Mr. FOSTER. Yes, there's a tough situation where if, for example, one State decides that, for their own purposes, they want to subsidize a class of electrical generation and then if you're in a multistate interconnected grid, that looks like dumping that will force, you know, other States' generation stations to close. And so this is a complex set of problems because one state's, you know, necessary subsidy for some purpose is another—it's protectionism viewed from other states. And in trying to understand how we—as—nationally deal with those misaligned incentives between the states and not have the federal government come in with yet a third set of misaligned incentives for their own political reasons is—will be an ongoing challenge.

And, let's see, I have now negative 19 seconds, so I'll yield back.

Chairman WEBER. I thank the witnesses for their valuable testimony and the Members for their questions. The record will remain open for two weeks for additional comments and written questions from members. This hearing is adjourned.

[Whereupon, at 3:04 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by The Hon. Bruce J. Walker

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

The Honorable Bruce J. Walker, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, Department of Energy; Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response, Department of Energy

Questions submitted by Rep. Dan Lipinski, Member, Committee on Science, Space, and Technology

1. **Recent cyberattacks on the U.S. energy grid show that more can and should be done to promote cyber preparedness. A key part of preparedness in any industry is ensuring that the workforce is equipped to protect against threats. In the interest of leading by example, what specific types of training, certifications, and/or standards does the Department of Energy use when evaluating its own personnel? Should the Department consider new or improved standards to better prepare all of its employees to help mitigate cyber risks?**

The Department of Energy (DOE) is committed to leading by example in the cybersecurity arena as we build and defend our networks and systems. Our capability to defend our Federal assets as a Department directly informs and brings credibility to our work supporting the cybersecurity of the energy sector.

A key component of this is ensuring that DOE has a fully staffed workforce with the right expertise to meet the ever-changing threat landscape. DOE is looking at efforts in other agencies to guide how we can continue to implement effective policies and procedures to ensure our cybersecurity workforce has the appropriate skills and multi-disciplinary expertise to meet known challenges, and that it has the flexibility to mitigate new threats, as well as fully utilizing OPM hiring authorities for cybersecurity professionals to ensure we get the best possible talent and are able to retain that talent over time. DOE is also increasing guidance and awareness training for all of our employees and key contractor personnel to support a united effort to respond to increasing cybersecurity threats through updated user-level cybersecurity policies in areas including handling of removable media and utilization of social media, as well as enhanced and more frequent phishing awareness training.

DOE's Offices of the Chief Information Officer (OCIO) and Human Capital coordinate with Federal Government-wide efforts and engage with private sector entities focused on training and education to identify and validate the certifications that best support our efforts to recruit, re-train, and retain the best talent for meeting the Department's critical cybersecurity workforce needs.

The OCIO also runs a biannual training program, called CyberFire, that is focused on cybersecurity incident response, including training in operational technology. CyberFire pulls in the best talent from the Department's national laboratories as instructors and mentors. We also

invite cybersecurity professionals from the energy sector, private industry, Department of Defense, and other Federal agencies to participate in CyberFire. We are expanding the coordination between DOE's Office of Cybersecurity, Energy Security, and Emergency Response (CESER) and OCIO to ensure that CyberFire meets the future needs of the Department and our public and private sector partners.

CESER supports preparedness through building capacity in the energy sector for incident response and information sharing, as well as advancing research and development to redesign the architecture to survive a cyber-attack. This requires multi-disciplinary expertise in power system engineering, energy sector operations, computer science, and cybersecurity. As such, CESER employees bring expertise from varied relevant backgrounds that, in combination, position CESER to support the energy sector in preparing for and reducing cyber-risk.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

The Honorable Bruce J. Walker, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, Department of Energy; Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response, Department of Energy

Questions submitted by Rep. Don Beyer, Member,
Committee on Science, Space, and Technology

1. **Please provide the costs to American businesses, especially U.S. manufacturing, of implementing the draft "Grid Memo" provided to the National Security Council and/or the Department of Energy's plan to implement President Trump's "Fuel-Secure Power Facilities" directive.**

The referenced "Grid Memo" was a pre-decisional document. I have not conducted a cost estimate to American businesses on the implementation of a proposal in a predecisional document.

2. **Please provide the costs to the American taxpayer of implementing the draft "Grid Memo" provided to the National Security Council and/or the Department of Energy's plan to implement President Trump's "Fuel-Secure Power Facilities" directive.**

The referenced "Grid Memo" was a pre-decisional document. I have not conducted a cost estimate to the American taxpayer on the implementation of a proposal in a predecisional document.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

The Honorable Bruce J. Walker, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, Department of Energy; Acting Assistant Secretary, Office of Cybersecurity, Energy Security, and Emergency Response, Department of Energy

Questions submitted by Rep. Jacky Rosen, Member,
Committee on Science, Space, and Technology

1. **This past March, I hosted a roundtable with Nevada stakeholders to discuss ways we can improve energy delivery and grid resiliency, strengthen cybersecurity, and build a capable energy workforce for a 21st century economy. I heard about the challenges these businesses, utilities, and non-profits face, including a lack of federal investment, shortage of skilled workers, and regulatory hurdles. One of the companies at the roundtable was a Nevada-based defense contractor with a focus on serving and protecting our military and critical national assets. They discussed operational technology, and how despite being the backbone of our nation's energy infrastructure, operational technology is not well understood or protected with standard IT methods. They also suggested that Congress create a new grant program or other funding source to help incentivize utilities to strengthen operational cybersecurity.**

    a. **What are your thoughts on a proposal like this?**

The Office of Cybersecurity, Energy Security, and Emergency Response's (CESER's) Cybersecurity for Energy Delivery Systems (CEDS) Research and Development (R&D) program enhances the reliability and resilience of the Nation's energy infrastructure by partnering with the energy sector to reduce the risk that a cyber incident might disrupt energy delivery. CEDS R&D incents energy sector entities, including utilities, to participate in cost-shared partnerships that support advanced technologies in the highrisk/high-reward research stages. The CEDS R&D program builds an R&D pipeline through partnerships with energy sector utilities, vendors, universities, national laboratories, and providers of cybersecurity services to the energy sector. A $25 million CEDS funding opportunity announcement (FOA), entitled "Industry Partnerships for CEDS Research, Development and Demonstration," closed on July 2, 2018. The FOA focuses on advancing cybersecurity tools and technologies for energy delivery control systems, and is now in the evaluation and selection phase.

Threat monitoring and detection is indeed less widespread in the complex operational technology (OT) environment of industrial control systems than on information technology (IT) networks. DOE's FY 2019 budget request supports a Cybersecurity for the Operational Technology Environment (CYOTE) pilot to enable OT data sharing and analysis capability with four pilot utilities. As part of this pilot, DOE is examining how we can work together with the electricity sector to leverage U.S. intelligence capabilities to prevent, detect, or delay a cyber-

attack on utility OT networks that could disrupt power. The CYOTE pilot is in the initial stages and could be expanded to other utilities.

2. **Since I've come to Congress, I've made it a priority to advocate for policies and programs that strengthen our grid and to better prepare our nation's electric infrastructure against cyber-attacks. For the past two years, I sent a letter to the House Appropriations Committee urging robust funding for DOE's Office of Electricity Delivery and Energy Reliability, and specifically the Smart Grid Research & Development (R&D) program. As you know, Smart Grid R&D develops the technologies, tools, and techniques needed to modernize the electric power grid and ensure the U.S. energy delivery system is secure, resilient, and reliable.**

    a. **How critical is federally-funded research to technology development and deployment for the electricity sector?**

As the grid evolves, cybersecurity technologies must adapt to new power system equipment. CESER is working in close partnership with Office of Electricity R&D programs to design cybersecurity into new modernized grid technology from the earliest stages. Funding for research for technology development and deployment is critical as we continue to address increasing and more sophisticated cyber and physical threats.

    b. **What are the scientific and industry consequences of defunding or stopping these R&D activities?**

The pace of innovation in the electricity system would likely slow, affecting national security through, among other issues, increased cybersecurity risk.

3. **Earlier this month, a memo from the Administration was leaked that details potential plans for the Secretary of Energy to save struggling coal and nuclear plants in the name of grid resilience and national security. In the wake of this memo surfacing, we have heard from many experts in industry who say that not only is this destructive to the purpose and efficiency of energy markets, but it would also not improve grid resilience in any meaningful way.**

    a. **What is the status of this proposal detailed in the memo?**

That document was pre-decisional. The Department of Energy is continuing to explore all options and no final decisions have been made.

    b. **Will the Department of Energy allow industry representatives and academic researchers with the appropriate clearances to view the classified threats to the grid that DOE cites?**

Where a need to know exists, CESER works with DOE's Office of Intelligence and Counterintelligence to provide classified threat briefings for participating energy sector

stakeholders. The need for academic participants in CESER activities to receive classified briefings has not yet arisen. Industry representatives with appropriate clearances, participating in CESER activities under the Cybersecurity Risk Information Sharing Program (CRISP) and CYOTE projects, for instance, have been provided classified threat briefings, as have members of the Electricity and Oil and Natural Gas Subsector Coordinating Committees.

CRISP analyzes near-real-time IT data from utilities using U.S. intelligence to detect cyber-attacks and threats, and delivers alerts and mitigations back to owners and operators.

The CYOTE pilot will enable OT data sharing and analysis capability with four pilot utilities for the complex OT environment.

Responses by Dr. John Sarrao

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

Dr. John Sarrao, Principal Associate Director, Science, Technology, and Engineering Directorate, Los Alamos National Laboratory

Questions submitted by Rep. Jacky Rosen, Member, Committee on Science, Space, and Technology

1. **This past March, I hosted a roundtable with Nevada stakeholders to discuss ways we can improve energy delivery and grid resiliency, strengthen cybersecurity, and build a capable energy workforce for a 21st century economy. I heard about the challenges these businesses, utilities, and non-profits face, including a lack of federal investment, shortage of skilled workers, and regulatory hurdles. One of the companies at the roundtable was a Nevada-based defense contractor with a focus on serving and protecting our military and critical national assets. They discussed operational technology, and how despite being the backbone of our nation's energy infrastructure, operational technology is not well understood or protected with standard IT methods. They also suggested that Congress create a new grant program or other funding source to help incentivize utilities to strengthen operational cybersecurity.**

    a. **What are your thoughts on a proposal like this?**

Effective approaches to cybersecurity are a key element of achieving and sustaining grid resilience. As I noted in my written testimony, Los Alamos believes that cyberphysical threats are one of the key challenges facing the grid today. We are actively working in this area, both researching and discovering new approaches to cybersecurity and working with academic, government, and industrial partners to translate these innovations to practice, with a particular focus on giving operators more effective tools to monitor for, detect, and respond to cyberphysical threats. While we do not have an opinion on specific proposals or funding mechanisms, we agree that enhanced investment in cybersecurity innovation would contribute positively to grid resilience.

2. **Since I've come to Congress, I've made it a priority to advocate for policies and programs that strengthen our grid and to better prepare our nation's electric infrastructure against cyber-attacks. For the past two years, I sent a letter to the House Appropriations Committee urging robust funding for DOE's Office of Electricity Delivery and Energy Reliability, and specifically the Smart Grid Research & Development (R&D) program. As you know, Smart Grid R&D develops the technologies, tools, and techniques needed to modernize the electric**

power grid and ensure the U.S. energy delivery system is secure, resilient, and reliable.

a. How critical is federally-funded research to technology development and deployment for the electricity sector?

b. What are the scientific and industry consequences of defunding or stopping these R&D activities?

Modernizing the electricity grid and enhancing its resilience is both a national security challenge and an important scientific frontier. As a result, Los Alamos National Laboratory is deeply committed to contributing to this effort, consistent with our broader national security capabilities, and we have been active and making important contributions for a number of years. Because of the long-term nature of the challenge and the innovation still required to achieve success, significant early-stage, pre-competitive research and development (R&D) is necessary, and we would agree that federal investment is appropriate and an important element of a broader R&D investment ecosystem.

Reduced or eliminated federal funding in this sector would surely slow progress in addressing key problems. Because Los Alamos approaches our work in grid resilience, as we do all R&D topics, from a capability perspective, applying and ultimately enhancing skill sets developed for our core nuclear security mission, it is difficult for us to quantify specific negative impacts that would result from particular funding decrements.

Responses by Mr. Robert Gramlich

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"*The Electric Grid of the Future*"

Mr. Robert Gramlich, President, Grid Strategies, LLC.

Questions submitted by Rep. Dan Lipinski, Member,
Committee on Science, Space, and Technology

1. **I notice there is a common trend among those that want to deny that human involvement is causing global temperatures to rise and our climate to change. They will say they do not know the extent to which humans are responsible. Or they will claim they are not a scientist in order to absolve themselves from taking a logical stand on a scientific issue. Yet we cannot afford to sit on our hands or pander to a certain political view when it comes to this issue, especially as we face more intense natural disasters and consider making major long-term investments in our infrastructure.**

   So as we consider potential infrastructure investments, should states and utilities consider climate change as it relates to the resilience of our electricity delivery system?

I think it is quite clear that the climate is changing, and various types of infrastructure need to withstand climate-driven threats that are of greater frequency and magnitude than in the past. The specific threats vary from region to region and include rising sea levels in coastal areas, and a wide range of more severe weather including more extremes for temperatures (both hot and cold), precipitation (both floods and droughts), and wind storms. States and utility planners must plan, authorize, and build new infrastructure and replace existing infrastructure to withstand these threats. The utility industry has seen examples such as Florida utilities building transmission and distribution assets designed to withstand higher wind speeds. The obvious and extremely unfortunate counter-example is Puerto Rico where vegetation management and other resilience activities were not well addressed leaving the island vulnerable. The extended outages caused by Hurricane Sandy also revealed that coastal transmission and distribution substations are vulnerable to rising seas and larger hurricane storm surges. The main job is for utilities and their state regulators to determine appropriate measures for hardening their distribution systems given plausible threats in their location, and providing for alternative local backup power sources for critical needs in the event of a widespread outage. DOE can help with research and analysis of those needs and opportunities.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

Mr. Robert Gramlich, President, Grid Strategies, LLC.

Questions submitted by Rep. Paul Tonko, Member,
Committee on Science, Space, and Technology

1. **It seems clear that additional interstate and interregional transmission will be needed to unlock our nation's clean energy potential. A number of organizations, including NREL, are studying the benefits of transmission grid expansion.**

    a. **What have been some of the initial findings of those studies?**

    b. **Have the estimated benefits exceeded the costs?**

Yes, I agree that additional interstate and interregional transmission will be needed. NREL is performing a "seams study." I described initial results of this study in my recent testimony to the House Energy and Commerce Committee. That testimony is posted here: https://docs.house.gov/meetings/IF/IF03/20180510/108283/HHRG-115-IF03-Wstate-GramlichR-20180510.pdf . In it I state that the benefits of the transmission investment exceed the costs by a factor of two to three. I look forward to the release of the final report at Iowa State University at the end of July.

I also cited benefit-cost studies for transmission plans in the Midwest by MISO and SPP, which are also in the range of two-to-three times benefits in excess of costs. If anything these benefit estimates are conservative, as many transmission benefits are not included in these analyses because they are difficult to quantify. There is uncertainty in forecasting benefits, but transmission is a great hedge against uncertainty because it can be used in various ways in different scenarios, often with power flowing in the opposite direction than expected.

2. **The costs of the proposed market interventions being floated by the Administration will be borne by ratepayers. You recently co-authored a report, "A Customer-focused Framework for Electric System Resilience," looking at the values of different measures to improve resilience from the perspective of those that will be asked to pay for it.**

    a. **What did your study find?**

The study had some key take-aways:

1). Bulk power system reliability has been defined and managed to include resilience (e.g., black start, system restoration);

2). Resilience should be measured in terms of impact on customers;

3). Most outages are caused by failures on low-voltage distribution power lines and – to a lesser extent – high-voltage transmission lines, not generation or fuel supply, and by routine rather than huge events;

4). The Rhodium Group found that generation inadequacy accounted for less than 1/10,000th of all customer-hours of outages, with fuel supply emergencies an even smaller share at fewer than 1 in 1.4 million.

5). Some threats are increasing: routine and severe weather, cyber & physical attack;

6). Some are not yet addressed: GMD, EMP;

7). Some questions related to the evolving fuel mix are being studied through standard reliability assessments of grid changes: fuel security, frequency stabilization following the loss of a large conventional generator, risks and opportunities of DERs and micro grids;

8). Budgets are limited, and investments have opportunity costs -- so the industry and regulators should maximize actual reliability and resilience impact per dollar with:

a). Measures that benefit customers most;
b). Measures that address multiple threats.

9). It would waste consumers' money to spend it on old uneconomic plants in an environment with high reserve margins where the incremental reliability benefit of the investment is nearly zero.. Spending on generation issues that cause less than 1 in 10,000 customer outage hours harms reliability and resilience by diverting scarce resources away from the transmission and distribution system failures that cause 99+% of customer outages. Subsidizing obsolete generators that can no longer compete in the market would also harm consumers and reliability by undermining the markets that have succeeded in providing reliable and affordable power.

b. How important is hardening of the distribution system?

Hardening of the distribution system generally ranks at the top of the list of activities that would benefit customers the most per dollar spent on it. That said, every activity will have diminishing returns at some point so regulators and utilities need to prudently evaluate threats in their region, options for mitigation, and the costs of various actions.

c. How did transmission investments, including deploying advanced transmission technologies, stack up— especially when compared to potential investments on the generation side?

Transmission infrastructure and advanced technologies to better monitor and control transmission systems rank high on the list of activities that will benefit customers. Transmission

can instantaneously deliver power from over a thousand miles to address any disturbance or energy shortfall on one part of the grid. There are new technologies for implementing modular power flow control systems, Dynamic Line Ratings, and topology optimization in particular that are under-utilized and can improve system monitoring and power flow to increase reliability and provide consumers with access to low-cost energy. These technologies are described in this white paper: https://watttransmission.files.wordpress.com/2018/03/watt-living-grid-white-paper.pdf

d. What is the relative value of subsidies to generators, as the Administration is suggesting?

Subsidizing old inefficient and relatively inflexible generation in an environment with excess capacity has near zero value to customers. Grid operators including PJM have calculated that once the power system has 20% reserve capacity, the incremental reliability value from additional capacity drops dramatically. With PJM at 33% reserve capacity for the foreseeable future, and most other power systems similarly saturated with excess capacity, subsidizing existing generators will do nothing for reliability and only exacerbate market challenges by delaying the market exit of those uneconomic resources. What the system needs is "flexibility," resources that can respond quickly to sudden needs to have more or less power at a given time and place. It is very sensible therefore that representatives of the DOE Office of Electricity are talking about modern storage technology in the context of resilience. In contrast, it is a non-sequitur for the agency to support old inflexible poor performing power plants in the resilience context since they do not provide needed flexibility, including regulating frequency, and they are just as vulnerable to cyber and physical attack as any other generator. In fact, these older resources create more reliability and resilience risk because they fail more frequently than newer generators and are more prone to tripping offline following a grid disturbance than newer resources like wind energy. Grid operators must keep expensive fast-acting reserves online as backup 24/7 in case a large conventional power plant abruptly fails, many times greater cost than the slight increase in need for the low-cost slower-acting reserves used to accommodate the gradual and predictable fluctuations in renewable energy supply.

3. **A number of proposed transmission projects have been mired in siting, permitting, and planning issues. Congress has tried to address delays caused by state and local governments in the past by creating a federal backstop authority.**

    a. What changes to existing federal authorities might be considered to ensure needed transmission projects are completed?

I agree that our permitting regime for transmission is not up to the task of the high voltage regional and inter-regional grid connections we need for reliability, efficiency, and clean secure energy access. Often states or even localities can block a line that benefits an entire region. Another approach is needed. I think Congress should review court decisions on this authority that have hampered its impact and separately look at whether this authority belongs fully at

FERC rather than DOE given the agencies' relative staffing capabilities and processes for infrastructure review. Transmission planning and cost allocation for transmission is also critical, and FERC has the authority to break the current logjam by expanding the pro-active planning and broad cost allocation policies adopted by ERCOT, MISO, and SPP to other regions, and in particular inter-regional transmission.

b. What factors should Congress consider when trying to strike the right balance between the rights of states and the federal oversight role on interstate transmission planning?

I agree there needs to be a balance. However currently there is almost no consideration given to regional or national benefits relative to local impact of transmission, in great contrast to how gas pipelines are permitted. A greater balance is needed to consider regional and national benefits of transmission.

c. What factors should Congress consider when trying to strike the right balance between streamlining the process for new transmissions projects and requirements for grid operators to consider non-wires alternatives?

There is plenty of need and opportunity for both infrastructure and alternative technology means of energy delivery. Transmission owners should consider more than one type of solution for identified needs. For many needs, such as the delivery of high-quality renewable resources from remote areas with few customers and little to no existing transmission, only expanding transmission helps. For many other needs, it makes sense to use new technologies, like dynamic line rating, topology optimization, and power flow control devices, that increase the utilization of both existing and new transmission lines. I believe FERC should review its planning guidance and the incentives inherent in current rate designs to ensure that the most economic option will tend to be chosen.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"The Electric Grid of the Future"

Mr. Robert Gramlich, President, Grid Strategies, LLC.

Questions submitted by Rep. Jacky Rosen, Member,
Committee on Science, Space, and Technology

1. **This past March, I hosted a roundtable with Nevada stakeholders to discuss ways we can improve energy delivery and grid resiliency, strengthen cybersecurity, and build a capable energy workforce for a 21st century economy. I heard about the challenges these businesses, utilities, and non-profits face, including a lack of federal investment, shortage of skilled workers, and regulatory hurdles. One of the companies at the roundtable was a Nevada-based defense contractor with a focus on serving and protecting our military and critical national assets. They discussed operational technology, and how despite being the backbone of our nation's energy infrastructure, operational technology is not well understood or protected with standard IT methods. They also suggested that Congress create a new grant program or other funding source to help incentivize utilities to strengthen operational cybersecurity.**

    a. **What are your thoughts on a proposal like this?**

That sounds important, but unfortunately I am not an expert on operational cybersecurity. I would be happy to try to identify other experts. I do know that cybersecurity threats exist for all energy sources, and NERC and FERC have developed stringent cybersecurity requirements. I also know that renewable plant owners take those threats seriously, having personally seen the stringent security protocols used at wind plant control centers.

2. **Since I've come to Congress, I've made it a priority to advocate for policies and programs that strengthen our grid and to better prepare our nation's electric infrastructure against cyber-attacks. For the past two years, I sent a letter to the House Appropriations Committee urging robust funding for DOE's Office of Electricity Delivery and Energy Reliability, and specifically the Smart Grid Research & Development (R&D) program. As you know, Smart Grid R&D develops the technologies, tools, and techniques needed to modernize the electric power grid and ensure the U.S. energy delivery system is secure, resilient, and reliable.**

    a. **How critical is federally-funded research to technology development and deployment for the electricity sector?**

b. What are the scientific and industry consequences of defunding or stopping these R&D activities?

(No response)

Responses by Dr. Joseph A. Heppert

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"*The Electric Grid of the Future*"

Dr. Joseph Heppert, Vice President for Research, Texas Tech University

Questions submitted by Rep. Jacky Rosen, Member,
Committee on Science, Space, and Technology

1. **This past March, I hosted a roundtable with Nevada stakeholders to discuss ways we can improve energy delivery and grid resiliency, strengthen cybersecurity, and build a capable energy workforce for a 21st century economy. I heard about the challenges these businesses, utilities, and non-profits face, including a lack of federal investment, shortage of skilled workers, and regulatory hurdles. One of the companies at the roundtable was a Nevada-based defense contractor with a focus on serving and protecting our military and critical national assets. They discussed operational technology, and how despite being the backbone of our nation's energy infrastructure, operational technology is not well understood or protected with standard IT methods. They also suggested that Congress create a new grant program or other funding source to help incentivize utilities to strengthen operational cybersecurity.**

    a. **What are your thoughts on a proposal like this?**

The task of securing our nation's critical national security assets in the face of increasing cyber threats is a concern I specifically addressed in my testimony. The promise of creating a more dynamic, efficient electrical grid system through the optimization of diverse energy generation and storage systems in a real-time system aided by Al technology might also increase the vulnerability of our grid systems to outside meddling. Concerted attacks on the integrity of electrical power distribution would represent a national security threat affecting a) general civil order and economic wellbeing, and b) the effectiveness of critical components of our nation's defenses in case of an attack within the continental U.S. or on our interests abroad.

Recognizing the magnitude of such a threat to national security and general civil order, it is entirely reasonable for Congress to formulate programs and incentives to ensure that the private energy sector and the defense industry are funding research and development activity in grid resiliency, cybersecurity, and a robust energy workforce. Opponents who would seek to capitalize on vulnerabilities in our electrical distribution system continue to invest in their ability to compromise our infrastructure; consequently, the threat profile is constantly evolving. Incentives to sustain research on defensive countermeasures should be an important element of assuring the protection of our critical infrastructure against interference by our competitors and adversaries.

Research universities have a key role to play in partnering with public utilities and the private sector to create a secure and resilient grid system. First, universities are at the forefront of applying Al and sensor technologies, as well as creating more robust high- power electrical components that can help to detect and mitigate cyber-intrusion events. Second, universities are a key source of the workforce the private sector needs to maintain its competence to meet rapidly developing cyber-threats and to construct a future electrical grid that exhibits resilience in the face of severe weather events and other environmental challenges. Creating incentives that generate lasting collaborations and partnerships among industry, defense contractors, and research universities would optimize the effectiveness of these investments.

This latter point is incredibly important. Many of the individuals whose skills are essential for building cybersecurity and resiliency in our critical electrical distribution and communications infrastructure have opportunities to pursue challenging and lucrative positions in other areas of high-technology industries. Universities consistently hear from our industry partners that recruiting the R&D talent required to sustain grid innovation is extremely challenging. By fostering a generation of engineers who have worked on grid cybersecurity and resiliency as part of their formative educational experience, collaborated with and interned in the electrical industry, and worked with professionals in national security positions, we create the best opportunity to cultivate a new generation of workers who will adopt these roles in their future careers.

2. **Since I've come to Congress, I've made it a priority to advocate for policies and programs that strengthen our grid and to better prepare our nation's electric infrastructure against cyber-attacks. For the past two years, I sent a letter to the House Appropriations Committee urging robust funding for DOE's Office of Electricity Delivery and Energy Reliability, and specifically the Smart Grid Research & Development (R&D) program. As you know, Smart Grid R&D develops the technologies, tools, and techniques needed to modernize the electric power grid and ensure the U.S. energy delivery system is secure, resilient, and reliable.**

    a. **How critical is federally-funded research to technology development and deployment for the electricity sector?**

As I noted in the answer to the first question, the cyberthreat landscape is in constant flux. We can expect the abilities of our adversaries to become more sophisticated and effective as time progresses. The electrical utility industry is under extreme pressure to restrain user rates. This pressure can become a disincentive to invest in new hardware and software technologies that will improve the resiliency and security of our electrical generation and distribution systems. The best way to ensure a critical threshold of investment in future technologies for grid security and resiliency is to provide federal funding as an incentive for industry to sustain its on R&D spending. Moreover, electrical utilities are unprepared to generate home-grown, cutting-edge talent in areas such as Al, sensor and control system innovation, and cybersecurity. Only by maintaining a Federally-sponsored research pipeline in these areas can we gain and maintain a

lead on adversaries dedicated to compromising security-critical infrastructure. As I have stated, I do not believe that the void in necessary research that would be created by a retreat from the Federal commitment to this area could be or would be filled by contributions from the private sector. Given the increasing threat profile in this area and its centrality to our national security, I would anticipate that substantially increasing the Federal research commitment in this area would be the appropriate response to the current situation.

b. What are the scientific and industry consequences of defunding or stopping these R&D activities?

In terms of the impact on TTU, in any given year drastic cuts in research on electrical grid and cybersecurity research could cost TTU upwards of $2.5 million in Federal sponsored research. Since roughly 80% of the funding in this area goes to salaries of students, postdoctoral researchers, and faculty, I estimate that TTU would lose between 10 and 15 individuals who are being trained in this area. This cuts directly into the pipeline of engineers who have the capacity to counter threats to our critical national infrastructure. This result would be multiplied many times on the national level. Researchers in academia are intensely entrepreneurial. They will choose to conduct research in areas where Federal investment is likely to be sustained. Increasingly, students in fields such as Al and cybersecurity recognize growth areas where challenging problems and opportunities for substantial compensation are creating high-quality jobs. They will vote with their feet if Federal support for research in these areas is substantially curtailed. The Federal government, given its role in ensuring national security, has a substantial interest in promoting and sustaining an environment where there is an adequate and committed workforce in grid resiliency and security. In a context where cyber-warfare events are likely to precede open hostilities with our economic and military adversaries, a retreat from Federal commitment to technology innovation and the building of human capacity in these areas would look incredibly short-sighted. Defunding technology innovation and depopulating the pipeline of top- flight engineers being trained in grid R&D would leave the U.S. population, our economic competitiveness, and our critical defense industries vulnerable to our adversaries in a manner that the public and the vast majority of policy makers would find unacceptable.

Appendix II

Additional Material for the Record

LETTER SUBMITTED BY REPRESENTATIVE DONALD S. BEYER, JR.

Congress of the United States
Washington, DC 20515

June 7, 2018

The Honorable Rick Perry
Secretary
U.S. Department of Energy (DOE)
1000 Independence Ave, SW
Washington, DC 20585

Secretary Perry:

We write regarding our concerns with President Trump's directive on "Fuel-Secure Power Facilities," the draft "Grid Memo" to the National Security Council, and FirstEnergy Solutions' bailout request. We ask that you cease the false narrative that bailing out uneconomic energy sources in competitive markets is needed for electrical grid resilience, and to cease attempting to use emergency authorities to intervene in planned power plant retirements. Using emergency authorities for unsubstantiated bailouts would be unprecedented intervention in U.S. energy markets at great taxpayer expense.

Last year, under your direction, the Department of Energy tried to use Section 403 authority under the Department of Energy Organization Act to initiate a rulemaking at the Federal Energy Regulatory Commission (FERC). This attempted rulemaking was to create new rules that would provide cost recovery to merchant coal and nuclear plants, asserting that they are essential to resiliency.[i] FERC unanimously voted to terminate that proposal, noting that the evidence did not support the Department's arguments. FERC wrote, "[T]he Proposed Rule's on-site 90-day fuel supply requirement would appear to permit only certain resources to be eligible for the rate, thereby excluding other resources that may have resilience attributes."[ii]

Since then, FirstEnergy Solutions sent a request asking that the Department invoke Federal Power Act Section 202(c) to find an emergency condition within the grid footprint of PJM Interconnection, LLC, a grid operator, to prevent PJM from retiring plants. FirstEnergy Solutions cited system resiliency as the reason to honor its request.[iii] When asked to comment, Assistant Secretary Bruce Walker stated that DOE would never use an emergency order under Section 202(c) Federal Power Act to prop up uneconomic generators.[iv] Republican FERC Commissioner Neil Chatterjee also explicitly said that retirements would not impinge on resilience.[v] PJM Interconnection's own analysis found that reliability could be maintained even in the face of planned coal and nuclear retirements.[vi]

However, despite the earlier repudiation from FERC of your section 403 request, and despite the rejection -- by both PJM and your own assistant secretary -- of the narrative that these bailouts are needed for grid resilience, you have entertained the idea of FirstEnergy's request in multiple congressional hearings, indicating a concern about nuclear and coal plant closures and explicitly citing the implications for the resilience and reliability of the grid. You also indicated a willingness to consider authorities other than 202(c), such as the Defense Production Act, to bail

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out these plants. Continuing this narrative is disingenuous, and while convenient for politically appeasing the current Administration's preferred energy sources, in real terms it would unnecessarily raise costs to customers and undermine the adoption of renewable energy sources.

More recently, President Trump issued a directive asking your Department to intervene in impending "fuel-secure power facilities" retirements.[vii] A corresponding DOE draft "Grid Memo" offering a plan to implement the directive was circulated before the National Security Council.[viii] It again offers a hypothetical doomsday energy scenario as justification to use emergency authorities to artificially prop up inefficient and uneconomic coal or nuclear power in the interest of national security. The memo failed to offer plausible support that such emergency bailouts are necessary for electrical grid resilience or national security. It also failed to rebut grid experts and grid operators' assessments, as well as widespread industry views, that such bailouts are not only unnecessary but in fact detrimental to wholesale electricity markets.[ix] Nor did it adequately explain how the proposed policy would be a legitimate use of the Defense Production Act and the Federal Power Act.

Using emergency authorities to bail out energy resources that are not critical to grid resilience and reliability is irresponsible at best, and sets a dangerous precedent of abusing these emergency authorities to bail out any pet project or pet energy source. Given the lack of any specific evidence suggesting that the affected closing plants are needed, the precedent could later be used to prop up *any* energy source that is uncompetitive in competitive markets. The President of the Electricity Consumers Resource Counsel, an association of large industrial electricity users, said that the latest DOE proposal would "devastate U.S. manufacturing."[x] The CEO of Exelon, the largest nuclear generator in the U.S., said the retirement of coal and nuclear plants do not constitute a grid emergency that warrants urgent intervention from the federal government.[xi]

Low-cost natural gas is squeezing out less cost-efficient energy sources in competitive markets. Traditionally, it has been the role of states to pursue specific energy portfolio policies. Changing that dynamic and *federally* subsidizing expensive, less cost-efficient energy sources without a well-justified policy rationale has the potential to raise the cost of electricity by staggering sums. The Department's section 403 proposal would have increased costs by $8 billion annually in PJM alone.[xii]

Grid operators must resort to more expensive and less cost-efficient resources such as coal when electricity demand is high. That does not mean such resources are essential to resilience, rather that they are more expensive and therefore used only when essential.[xiii] In contrast, winter winds ensure that wind energy is a strong performer during severe winter weather, and wind has contributed more than its expected share to PJM's grid during the recent cold snaps over the past few winters.[xiv] Reducing physical and market barriers to wind resources in regions like PJM's footprint could help to cost-effectively and reliably operate the grid during extreme winter weather, but your department is apparently not looking to eliminate such barriers.

Instead, the Department is proposing budget cuts that undermine resiliency tools, such as energy storage.[xv] Energy storage helps balance electricity demand with supply -- regardless of the energy source.

Your department is also ignoring the true cause of most disruptions to our electricity system: downed power lines. Customers are far more likely to suffer power outages from downed lines on the distribution system, with more than 6 million miles of wires and poles carrying power.[xvi] According to a January 2017 DOE report, 90 percent of electric power interruptions stem from disruptions on the distribution system.[xvii] The Department could assist by supporting distributed energy resources sited near customers, such as customer-sited solar, batteries and electric vehicle chargers, to mitigate these distribution failures.[xviii]

We ask you to reject the political narrative and pressure to adopt policies that artificially and unnecessarily prop up uneconomic energy sources, which will raise costs on American taxpayers. We stand ready to work with you to more effectively enable distributed energy sources sited near customers and adequately fund technologies like energy storage that help with resilience.

Sincerely,

Donald S. Beyer Jr.

Eliot L. Engel

Mark Pocan

Jerry McNerney

Debbie Wasserman Schultz

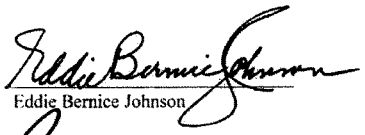
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Daniel W. Lipinski

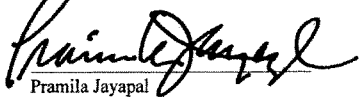
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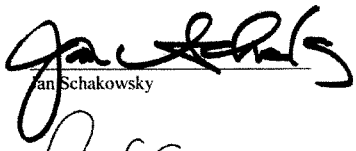

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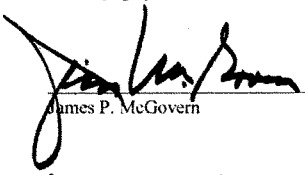

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Lucille Roybal-Allard

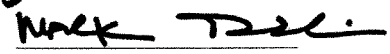

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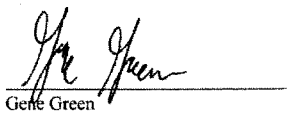

Mike Quigley

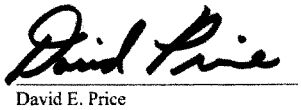

Jan Schakowsky


James P. McGovern

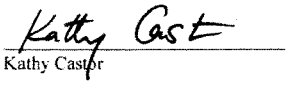
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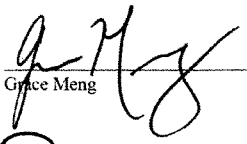

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Gene Green

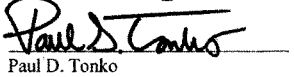

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Diana DeGette


Kathy Castor

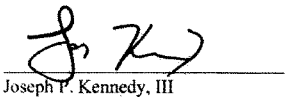

Grace Meng


Jackie Speier

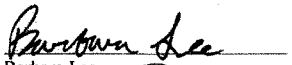

Paul D. Tonko



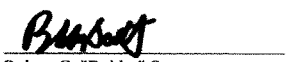
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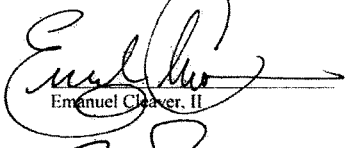
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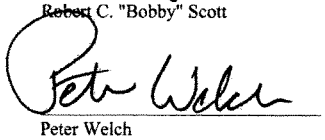
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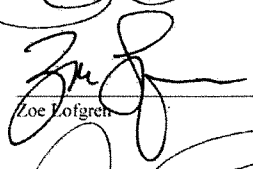
Robert C. "Bobby" Scott



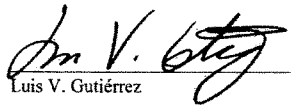
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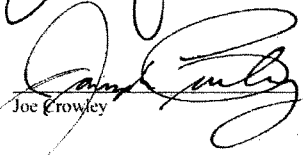
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Zoe Lofgren



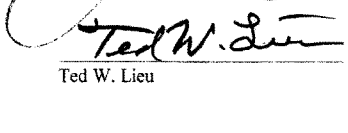
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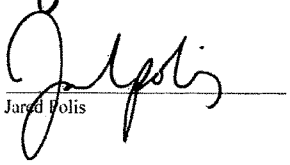
Joe Crowley



Suzanne Bonamici



Ted W. Lieu



Jared Polis

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