POWERING AMERICA: DEFINING RELIABILITY IN A TRANSFORMING ELECTRICITY INDUSTRY

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON ENERGY AND COMMERCE

HOUSE OF REPRESENTATIVES

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SUBMITTED MATERIAL

POWERING AMERICA: DEFINING RELIABILITY IN A TRANSFORMING ELECTRICITY INDUSTRY, PART 1

THURSDAY, SEPTEMBER 14, 2017

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

The subcommittee met, pursuant to call, at 10:00 a.m., in room 2123, Rayburn House Office Building, Hon. Pete Olson (vice chairman of the subcommittee) presiding.

Members present: Representatives Olson, Barton, Shimkus, Murphy, Latta, McKinley, Kinzinger, Griffith, Johnson, Long, Bucshon, Flores, Cramer, Walberg, Walden (ex officio), Rush, McNerney, Green, Doyle, Castor, Tonko, Loebsack, Butterfield, and Pallone (ex officio).

Staff present: Ray Baum, Staff Director; Elena Brennan, Legislative Clerk, Energy/Environment; Karen Christian, General Counsel; Wyatt Ellertson, Research Associate, Energy/Environment; Adam Fromm, Director of Outreach and Coalitions; Tom Hassenboehler, Chief Counsel, Energy/Environment; Jordan Haverly, Policy Coordinator, Environment; A.T. Johnston, Senior Policy Advisor, Energy; Mary Martin, Deputy Chief Counsel, Energy/Environment; Alex Miller, Video Production Aide and Press Assistant; Brandon Mooney, Deputy Chief Energy Advisor; Annelise Rickert, Counsel, Energy; Dan Schneider, Press Secretary; Jason Stanek, Senior Counsel, Energy; Madeline Vey, Policy Coordinator, Digital Commerce and Consumer Protection; Andy Zach, Senior Professional Staff Member, Environment; Priscilla Barbour, Minority Energy Fellow; Rick Kessler, Minority Senior Advisor and Staff Director, Energy/Environment; John Marshall, Minority Policy Coordinator; Alexander Ratner, Minority Policy Analyst; Andrew Souvall, Minority Director of Communications, Member Services, and Outreach; and Tuley Wright, Minority Energy and Environment Policy Advisor.

Mr. OLSON. The hearing will come to order.

Good morning and welcome. We find ourselves this morning with a bit of a challenge on the House floor. Votes may start within 5 minutes, multiple roll call votes, may be up to 1½ hours voting on the House floor.

I had a great opening statement written by my Texas constituent Annelise. I will not give it but ask unanimous consent to put that in the record.

Without objection, so ordered.
[The prepared statement of Mr. Olson follows:]

PREPARED STATEMENT OF HON. PETE OLSON

Today's hearing is part one in the committee's efforts to address reliability of the Nation's electricity system. Today we have the opportunity to hear from the regulators in charge of the reliable delivery of electricity to millions of Americans.

I want to start by sending my thoughts and prayers to the family of former Senator Pete Domenici. He was a dedicated public servant and a titan on energy policy. He will be missed.

I also want to take a minute to acknowledge all those affected across the United States by both Hurricane Harvey—like the people of my district—and Hurricane Irma. These natural disasters have left the electric industry with one of the largest and most complex power restoration efforts in United States history.

To that end, thank you, Acting Assistant Secretary Hoffman, here today, for working with my staff in the days after Hurricane Harvey to give us an update on gasoline supply in Texas. My district is trying to get back on its feet, and it will take a united Government to help. Given how much energy Texas contributes to the American economy, I hope you will continue to work on post-Harvey issues in the weeks and months ahead.

Electricity is a fundamental and essential part of our everyday lives. A system failure impacts our health, wealth, and national security. These impacts were felt firsthand in the wake of Hurricanes Harvey and Irma.

The electricity sector is experiencing significant change—driven by fuel costs, decreases in electricity demand, advances in technology, and evolving consumer preferences. These changes present new challenges and opportunities.

Our Nation's electricity is supplied by a diverse mix of fuel sources- natural gas, coal, nuclear, wind, hydropower, solar, and other technologies. Each of these have attributes that help system operators protect reliability. Harvey and Irma highlight the importance of a reliable grid that is not too dependent on one source of energy.

It also showed the importance of being prepared. This committee was instrumental in passing H.R. 3050, the Enhancing State Energy Security Planning and Emergency Preparedness Act. Our bipartisan bill gives States the flexibility they need to address local energy challenges. H.R. 3050 reauthorizes the Department of Energy's State Energy Program. It strengthens our energy emergency planning and preparedness efforts. States need all the tools in the tool box to address fuel supply, infrastructure resilience, energy security, and emergency preparedness.

The second part of this important hearing, which will be held at a later date, will include a panel of witnesses representing different kinds of resources and technologies. These witnesses will provide helpful insight into differences on our grid, but also how sources of energy are working together.

I want to extend a warm welcome to our panel of witnesses. This is the Energy Subcommittee's first Government panel this congress. Chairman Chatterjee, we are happy to have you join us. We are breathing a sigh of relief now that FERC has quorum. I want you back at your desk ASAP. I also want to thank you, Mr. Cauley and Assistant Secretary Hoffman, who are joining us despite all the work being done at NERC and DOE this week. On behalf of the committee, we truly appreciate you being here.

Mr. OLSON. Mr. Rush, would you like to speak, or put your statement for the record?

Mr. RUSH. For the record.

OK. Guys, moving forward, we have three witnesses here. We have Mr. Chatterjee, Ms. Hoffman, and Mr. Cauley.

You guys have 5 minutes for opening statements.

Mr. Chatterjee, the head of FERC. You have 5 minutes.

STATEMENTS OF NEIL CHATTERJEE, CHAIRMAN, FEDERAL ENERGY REGULATORY COMMISSION; PATRICIA HOFFMAN, ACTING ASSISTANT SECRETARY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, DEPARTMENT OF ENERGY; AND GERRY W. CAULEY, PRESIDENT AND CHIEF EXECUTIVE OFFICER, NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

STATEMENT OF NEIL CHATTERJEE

Mr. CHATTERJEE. Thank you, Mr. Chairman, Ranking Member Rush, members of the subcommittee, for the opportunity to be before you today. Before I begin my remarks, I just want to very briefly reflect on the passing of Senator Domenici who passed away yesterday, former chairman of the Senate Energy Committee, who was a leader in this space. And he will be remembered.

I would like to start by taking a moment to acknowledge all of those impacted by Hurricanes Harvey and Irma. The loss of life and widespread devastation wrought by the storms has been absolutely heartbreaking to see. I know I speak on behalf of those in the room and for Americans across the country when I say that our thoughts and prayers are with those affected at this difficult time. We know the road ahead will not be easy, but we will be with you every step of the way.

It was good to see Congress act swiftly to begin providing some of the resources that are needed to those relying on it. We at the Federal Energy Regulatory Commission are ready to do our part as well.

It is times like these that also remind us how important the reliability and resiliency of the electric grid is in our day-to-day lives. Rebuilding from these storms is going to take time. But I have been inspired by the way that the brave men and women of the utility industry have already stepped forward to help.

Crews from all over the country are assisting in this effort. In addition, FERC and NERC have issued a joint statement to encourage mutual assistance and assure companies that they won't be penalized for helping restore service. FERC also granted an extension on filing deadlines so that people and companies could focus on what is most important: recovery.

And finally, in response to the loss of refineries due to the storms, the Commission issued an emergency pipeline waiver to accelerate the delivery of much-needed fuel and to help ensure the continued flow of gasoline to the Northeast. We will continue to keep all those affected by Hurricanes Harvey and Irma in our prayers as they work to rebuild their homes and lives.

While this is a transformational and exciting period for the electric power industry, we must be mindful that developments not threaten the robustness or security of the electric grid. FERC supports the reliability and the resiliency of the grid in several ways. Congress entrusted FERC with the responsibility to approve and enforce mandatory reliability standards for the grid in 2005. FERC relies on NERC to develop and propose new or modified reliability standards for FERC's review. These standards include both physical and cybersecurity standards.

Much of this is covered in my written testimony. So, in the interest of time, I am going to speed ahead and just say that a reliable and resilient grid requires the development of needed energy infrastructure. FERC supports that development through its statutory responsibility to authorize the construction of certain energy infrastructure, such as interstate natural gas pipelines, liquefied natural gas terminals, and non-Federal hydropower generation. While the lack of a quorum has rendered the Commission unable to act on applications for such projects for much of this year, I am pleased to report that FERC is now addressing the backlog and will continue to make steady progress in the coming weeks and months. I am proud to report that, since the restoration of the quorum, we have put out 62 orders and will continue to do that.

Certainly, FERC's efforts in all of these areas covered in my written testimony will continue to involve cross-sector, interagency, and public-private coordination. Working with our Federal partners, State colleagues, relevant industries, and other stakeholders, FERC will continue to seek ways to ensure the reliability and resiliency of the electric grid.

I am committed to working with the subcommittee to continue these efforts, and I would like to reiterate my appreciation to the chair and ranking member for holding this critical hearing. Thank you for allowing me the opportunity to be with you today. I apologize for the abbreviated remarks, and I would be happy to answer any questions you may have.

[The prepared statement of Mr. Chatterjee follows:]

Testimony of Neil Chatterjee
Chairman, Federal Energy Regulatory Commission
Before the Committee on Energy and Commerce
Subcommittee on Energy
United States House of Representatives
September 12, 2017

Introduction

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee: Thank you for the opportunity to appear before you today to discuss the subject of defining reliability in a transforming electricity industry. I appreciate the Subcommittee's attention to this important issue.

While this is an exciting and transformational period for the electric power industry, we must be mindful that developments not threaten the robustness or security of the electric grid. The reliability and resiliency of the electric grid is vital to our nation.

The Federal Energy Regulatory Commission's Role in Supporting Reliability and Resiliency of the Electric Grid

The Federal Energy Regulatory Commission (FERC) is an independent agency with jurisdiction that covers a wide array of energy matters. FERC supports the reliability and resiliency of the electric grid in several ways. My testimony today will discuss FERC's ongoing work to support reliability and resiliency through: first, regulatory oversight of reliability standards, including more recent efforts to address the cyber and physical security of the electric grid; second, regulatory oversight of rates and markets; and third, infrastructure development.

Reliability

The Energy Policy Act of 2005 gave FERC the new responsibility to approve and enforce mandatory reliability standards for the grid. This authority is limited to the "bulk-power system," as defined in section 215 of the Federal Power Act (FPA), and excludes Alaska and Hawaii, as well as local distribution systems.

Under FPA section 215, FERC cannot directly write or modify reliability standards, but must rely on the Electric Reliability Organization (ERO) to perform this task. In 2006, FERC certified the North American Electric Reliability Corporation (NERC) as the ERO. Under the section 215 construct, NERC develops and proposes for FERC's review new or modified reliability standards. In addition to approving or remanding a reliability standard proposed by NERC, FERC may direct NERC to address a specific matter through a new or revised reliability standard and has done so on various occasions.

Once FERC approves a proposed standard, it becomes mandatory and enforceable in the continental United States, and is applicable to the users, owners and operators of the bulk-power system. An entity that violates an approved standard may be subject to enforcement by either NERC or FERC, and may be subject to a monetary penalty of up to one million dollars per day per violation.

With guidance from FERC, NERC and industry stakeholders that assist NERC in developing proposed standards have put in place a robust set of "baseline" reliability standards to address day-to-day grid reliability issues, like tree trimming, relay setting, communications, system planning, and emergency operations. The maturation of these "baseline" reliability standards has allowed FERC and NERC to focus more of their efforts on standards related to cybersecurity, physical security, and the potential grid impact of a geomagnetic disturbance (GMD).

In 2008, FERC approved NERC's first set of proposed cybersecurity standards, referred to as "Critical Infrastructure Protection" or "CIP" standards. Since then, FERC has worked with NERC on a number of increasingly robust versions of the CIP standards, which address how to identify, categorize and protect cyber assets and systems; processes and procedures for maintaining these systems; and ensuring that only appropriate personnel have access to these systems, among others. In 2016, pursuant to CIP standards approved by FERC, utilities began to implement a tiered approach to cybersecurity. This approach provides protection for cyber assets that is commensurate with their impact on the bulk-power system. In addition, pursuant to FERC's direction, NERC is currently developing a reliability standard addressing the supply chain for industrial control system hardware, software, and related services associated with the bulk-power system.

In 2014, FERC directed NERC to develop a reliability standard that addresses physical security threats and approved NERC's proposed physical security reliability standard later that year. The physical security reliability standard requires responsible entities to mitigate assessed vulnerabilities to critical transmission facilities through resiliency or security measures designed to deter, detect, delay, assess, communicate, and respond to potential physical threats and vulnerabilities. In addition, in 2013, FERC directed NERC to develop reliability standards to address the potential impact of a geomagnetic disturbance. Subsequently, NERC developed, and the Commission approved, two GMD-related standards.

FERC, along with NERC and the industry, has dedicated significant attention to improving grid resilience. Resilience efforts cover a range of actions that grid owners and operators can take to reduce the risks associated with the loss of individual or multiple assets and to improve recovery and restoration following such losses. As an example of FERC's efforts, the Commission has issued orders to provide clarity on how it will address services provided by Grid Assurance, a company created by several electric utilities to enhance grid resilience and protect customers from prolonged outages. Specifically, Grid Assurance provides subscribing electric utilities with timely access to an inventory of emergency spare transmission equipment, including transformers, that otherwise can take months or longer to acquire.

Separate from the regulatory actions discussed above, FERC also uses a voluntary and collaborative approach with its jurisdictional entities, the states, and other federal agencies to help improve grid resilience and security. This approach can be more agile and focused and was developed in response to the growing cyber and physical security threats targeting our nation's energy infrastructure. This work has been led by FERC's Office of Energy Infrastructure Security. These efforts include working closely with industry to help them assess their vulnerabilities, facilitate open and closed briefings regarding the current and emerging threats that they face, and help them identify and implement best practices as appropriate to address any issues that are found. In addition, FERC has worked closely with the states. These efforts include facilitating classified briefings, assisting with the development of state resources and guidelines, and participating in state and regional cybersecurity and physical security exercises. To help accomplish these objectives, FERC collaborates extensively with other federal and private entities. Some recent and ongoing examples of this collaboration include work with the Department of Homeland Security, the Transportation Security Administration (natural gas pipelines), the Coast guard (LNG terminals), the Office of the Director of National Intelligence, the Department of Energy, and NERC.

Rates and Markets

FERC also works to ensure reliability through its oversight of jurisdictional wholesale energy, capacity, and ancillary services markets. FERC ensures that rates, terms, and conditions of service, including market rules and market structures, are just and reasonable and not unduly discriminatory or preferential. For some ancillary services that provide reliability support, the Commission has determined that the provision of the service is best met through a requirement that all resources provide the service as a condition of interconnection, rather than through a market mechanism. The interconnection of a new resource must maintain reliability and, in some circumstances, the cost of providing a service may not warrant the time and expense needed to develop a market mechanism to procure the service. For other services providing reliability support, FERC has undertaken several efforts to ensure that those services are properly compensated, and that energy, capacity, and ancillary services markets send correct price signals to support the investment in and retention of resources and other infrastructure needed for reliability.

As part of these efforts, FERC has been evaluating the essential reliability services necessary for the reliability of the grid. The transformation of the nation's power supply portfolio, particularly the changing resource mix, makes it important to focus on the resources providing these types of services to the grid. However, it is important to recall that states generally have jurisdiction over the resource mix in their individual states, and that FERC has generally remained resource- and fuel-neutral in fulfilling its core obligations to ensure the reliability of the bulk-power system and to maintain just and reasonable wholesale electric rates. That said, FERC's ongoing evaluation of the grid includes the availability of essential reliability services, including the sufficiency of such services, the types of resources for providing such services, and the compensation for providing such services, when appropriate. As a consequence of this evaluation, FERC issued Order No. 827, eliminating the exemption for new wind generators from the requirement to provide reactive power. Similarly, FERC issued Order No. 828, requiring newly interconnected small generators (no larger than 20 megawatts) to ride through abnormal frequency and voltage events and not disconnect during such events, similar to the requirements already in place for large generators. In addition, FERC is considering requiring all resources newly interconnecting to the grid to install and enable primary frequency response capability as a condition of interconnection. While this proposal is still under review, in one of the first orders issued upon restoration of a quorum, my colleagues and I issued a notice seeking further information from industry and interested stakeholders on primary frequency response capability.

As system needs evolve, FERC continually evaluates market rules to help meet those needs. FERC seeks to establish market rules that ensure the cost effective provision of the services needed to address system needs. While FERC prefers to rely on competitive forces when reasonable, it recognizes that traditional regulatory measures are sometimes necessary in wholesale electricity markets. Also, these changes affect each region of the country differently, and FERC has endeavored to allow markets to evolve to address unique regional needs while taking generic action when it is warranted. For instance, in 2011, FERC issued Order No. 755, which addressed compensation for frequency regulation in wholesale markets operated by Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs). Frequency regulation is a type of ancillary service provided by resources that supports reliability by balancing supply and demand on the transmission system. Prior to Order No. 755, compensation methods for frequency regulation service failed to recognize the greater amount of frequency regulation provided by faster-ramping resources. To address this problem, Order No. 755 required RTOs and ISOs to compensate frequency regulation based on the actual amount of frequency regulation service provided. This allowed market operators to take advantage of the capabilities of faster-ramping resources to improve operational and economic efficiency of the transmission system and reduce costs to consumers in organized wholesale markets.

In June 2014, FERC initiated a proceeding to actively explore issues related to price formation in wholesale markets in order to improve competition, promote necessary investment, and produce meaningful price signals that clearly indicate where new supply and investment are needed. The goals of price formation are to (1) maximize market surplus for consumers and suppliers; (2) provide correct incentives for market participants to follow commitment and dispatch instructions, make efficient investments in facilities and equipment, and maintain reliability; (3) provide transparency so that market participants understand how prices reflect the actual marginal cost of serving load and the operational constraints of reliably operating the system; and (4) ensure that all suppliers have an opportunity to recover their costs.

To facilitate engagement from various stakeholders, FERC held three workshops and published four technical papers on price formation issues. It also asked RTOs and ISOs to submit reports on certain price formation topics to provide FERC with an update on current practices in these areas and help it identify best practices. Based on the discussion, comments, and reports received, FERC identified particular challenges to proper price formation and proposed solutions. Most of the areas FERC identified represented opportunities for incremental improvement, with some attention to areas in which incremental improvement would better value resource attributes, such as flexibility, that contribute to reliability.

For example, in June 2016, FERC issued Order No. 825, which addressed certain practices that failed to provide appropriate price signals for resources to follow dispatch instructions and respond to actual system conditions. To address this problem, FERC required RTOs and ISOs to align dispatch intervals and settlement intervals, and required RTOs and ISOs to trigger shortage pricing for any dispatch interval during which a shortage of energy or operating reserves occurs. Both of these reforms help maintain reliability by facilitating accurate market signals of system conditions, which encourages resources to follow commitment and dispatch instructions. These required changes in market rules provide incentives for more flexible resources and encourage efficient investments in facilities and equipment.

In November 2016, FERC issued Order No. 831 which addressed problems with certain aspects of energy offer caps. Among other things, FERC found that existing offer caps may prevent RTOs and ISOs from dispatching the most efficient set of resources, suppress market prices below the cost of production, and prevent resources from recovering their costs which would discourage them from offering energy into the market. To address these problems, FERC required RTOs and ISOs to revise their energy offer caps to permit energy costs above $1,000/MWh to be used to set price if they are verified in advance, and required RTOs and ISOs to provide resources the opportunity to recover energy costs outside of the market in certain circumstances if they are subsequently verified. These reforms help support reliability by providing accurate price signals to encourage resources to offer energy, particularly during times of system stress, and they also encourage efficient investment in resources.

FERC is also considering changes relating to the pricing of fast-start resources, uplift cost allocation, and transparency into reporting practices in certain RTO and ISO markets. These efforts, which are still ongoing, would support reliability by, among other things, supporting investment in facilities and equipment, particularly those affecting local reliability.

Finally, there has been much interest in FERC's efforts to foster further discussion regarding the relative roles of wholesale markets and state policies in the Eastern RTOs and ISOs in shaping the quantity and composition of resources needed to cost-effectively meet future reliability and operational needs. In May 2017, FERC held a two-day technical conference on these important issues, featuring a variety of stakeholders and also solicited comments from the public. FERC continues to engage with stakeholders and review comments on these issues.

Infrastructure

A reliable and resilient grid requires the development of needed energy infrastructure. FERC supports infrastructure development through its statutory responsibility to authorize the construction of certain energy infrastructure, such as interstate natural gas pipelines, liquefied natural gas terminals, and non-federal hydropower generation. While the Commission has been unable for much of this year to act on applications for such projects, the Commission is addressing the backlog and will continue to make steady progress in the coming weeks and months.

Conclusion

Given FERC's responsibilities and efforts as to reliability and resiliency, my colleagues and I reviewed the Department of Energy Staff Report on Electricity Markets and Reliability with great interest. The report highlights many of the challenges and changing resource landscape that FERC continues to consider. I will work with my colleagues and FERC staff to analyze the recommendations and areas for further study identified in the report.

Certainly FERC's efforts in these areas will continue to involve cross-sector, interagency and public-private coordination. Working with our federal partners, state colleagues, industry and other stakeholders, FERC will continue to seek ways to ensure the reliability and resiliency of the electric grid. And, of course, I look forward to working with this Subcommittee to continue these efforts.

I would like to once again thank the Members for allowing me the opportunity to be here today. I would be happy to answer any questions you may have.

Mr. OLSON. Thank you, Chairman Chatterjee.

The Chair now calls upon Ms. Patricia Hoffman. She is the Acting Under Secretary for Science, the Acting Assistant Secretary of the Office of Electricity at the Department of Energy.

You have 5 minutes, ma'am.

STATEMENT OF PATRICIA HOFFMAN

Ms. HOFFMAN. Chairman Upton, Vice Chairman Olson, Ranking Member Rush, and distinguished members of the subcommittee, I appreciate the opportunity to discuss with you electricity reliability issues in a rapidly transforming electricity industry. The U.S. electric sector is in the midst of sweeping changes. Looking ahead, I see little reason to expect that this process will slow down or that we will reach new equilibrium any time soon. Accordingly, I think the fundamental challenge is now to understand this process and manage it so that our Nation's electric infrastructure remains reliable, affordable, and resilient.

Before I discuss any further details, I would like to echo the comments by Chairman Chatterjee and that our thoughts and prayers are there for those that are affected. Our organization also provides energy-related expertise to FEMA and the administration as part of our emergency response activities. We have been actively engaged in the response, recovery, and rebuilding efforts from Hurricane Harvey and Hurricane Irma. The actions that the departments have taken are in support of a whole-of-Government response to these disasters and includes deploying 26 people to State emergency operation centers, Regional and National Response Coordination Centers. We have authorized up to 5.3 million barrels of oil for exchange from the Strategic Petroleum Reserve. We have supported State and regional fuel waivers under the jurisdiction of EPA and hosted coordination calls with DOE and emergency response personnel in the electric sector, the oil and natural gas sector, and State energy offices.

As Secretary Perry has noted on numerous occasions, America is blessed to have the incredible energy systems and resources we have today. The millions of dedicated men and women who work in the electric industry and are providing response activities to restore power, to move fuels, and to repair infrastructure are doing a tremendous job and should be recognized for their dedication and service.

Over the last several months, DOE, led by my office, has explored numerous issues central to protecting the long-term reliability and resiliency of the electric grid. We are seeking to inform policymakers of the facts and trends in the electric sector and provide a common focal point of discussion for all affected stakeholders.

In addition, we do research at our national laboratories with our industry partners. We have focused on new technologies for operating, planning, and monitoring and protecting the grid. The Department announced on Tuesday up to $50 million to national laboratory-led teams focused on resilience and cybersecurity.

In order to keep my comments short, I just want to say, in conclusion, Secretary Perry and our DOE team look forward to a thoughtful conversation focused on reliability, affordability, and resilience in the electric system. The implications are profound, and we have one electric grid. And we are more dependent on it than ever for our economic well-being and national security. The grid must function, and it must function well in that it must meet a number of competing technical and economic requirements.

And, for me, managing this change means we must think about the grid holistically in a single interactive set of policies; we must monitor the grid's characteristics and performance; we need to develop a more systematic way of looking ahead; and, finally, we must manage change with new processes and practices for collaboration that requires coordination between the Federal and private-sector partners.

Thank you, and I look forward to your questions.

[The prepared statement of Ms. Hoffman follows:]

Written Testimony of Acting Assistant Secretary Patricia Hoffman

Office of Electricity Delivery and Energy Reliability

U.S. Department of Energy

Before the

House Committee on Energy and Commerce

Subcommittee on Energy

September 14, 2017

Chairman Upton, Ranking Member Rush, and distinguished Members of the Subcommittee: I appreciate the opportunity to discuss with you electric reliability issues in a rapidly transforming electricity industry. The issue of grid resiliency is inextricably linked to this vital topic.

The U.S. electricity sector is in the midst of sweeping changes. Looking ahead, I see little reason to expect that this process will slow down or that we will reach some new equilibrium anytime soon. Accordingly, I think the fundamental challenge now is to understand this process and manage it, so that our Nation's electric infrastructure remains reliable, affordable, and resilient.

The mission of the Office of Electricity Delivery and Energy Reliability is to develop innovative, cutting-edge solutions. The Department leverages the technical capabilities of the National Laboratories to focus on early-stage research and transformative projects.

Our organization also is on point for providing energy-related expertise to FEMA and the Administration as part of our emergency response activities. We have been actively engaged in the response and recovery efforts for Hurricane Harvey and Hurricane Irma.

Actions that the Department has taken in support of the whole-of-government response to these major disasters include: deploying 23 people in support of state emergency operations centers, regional and national response coordination centers (FEMA); authorized up to 5.3 million barrels of oil for exchange from the Strategic Petroleum Reserve; supported state and regional fuel waivers under the jurisdiction of EPA; and hosted coordination calls with DOE and response personnel in the electric sector, oil and natural gas sector and state energy offices.

Exploring Key Issues

The Administration's priorities are focused around innovation, regulatory reform and infrastructure investments. Our organization has been developing innovative solutions to address transmission permitting issues, improved visibility and coordination. We all know that the issues affecting the grid are complex, have regional variations, and lack simple answers.

Over the last several months, DOE staff—led by my office—have explored issues central to protecting the long-term reliability and resiliency of the electric grid. We are seeking to inform policymakers of facts and trends in the electricity sector, and provide a common focal point of discussion for all affected stakeholders.

We have been particularly focused on three issues:

- The evolution of wholesale electricity markets, including the extent to which Federal policy and the changing electricity fuel mix affect grid reliability;
- Whether wholesale and capacity markets are adequately compensating attributes such as on-site fuel supply, storage and other factors that strengthen grid resilience; and
- The extent to which regulations and legislation affect early retirement of baseload generation plants.

Critical Issues

There are several critical issues central to protecting the long-term reliability and resiliency of the electric grid:

- Changing circumstances are challenging electricity markets. While centrally-organized markets (managed by regional transmission organizations, or RTOs, and independent system operators, or ISOs) have achieved reliable wholesale electricity delivery with economic efficiencies in their short-term operations, changing circumstances are challenging the ability of both centrally-organized and, to a lesser extent, vertically-integrated markets to sustain these efficiencies over the long term.
- Markets recognize and compensate reliability, and must evolve to continue to compensate reliability, but more work is needed to address resilience. While reliability is important, recent disruptive events such as the Polar Vortex, Superstorm Sandy, and other major disruptions that have cascading impacts on other sectors demonstrate the critical need for improved system resilience. Markets are beginning to recognize and compensate resilience-enhancing resource attributes, including fuel assurance. More work is needed to ensure a resilient grid.
- A major contributor to coal and nuclear plant retirements has been the economic advantages of natural gas-fired generation (i.e., low fuel prices and efficient new designs for generators). Three additional factors have contributed to the retirements: low electricity demand; the low operating costs of variable renewable energy (VRE) resources, which leads to their being dispatched before baseload resources; and the cost of new investments needed to keep existing plants in compliance with regulatory requirements.
- Evolving market conditions and the need to accommodate VRE resources have led to the need for increased flexibility in the operation of generation and other grid resources. Some generation technologies originally designed to operate as baseload were not

intended to operate flexibly, and in nuclear power's case, do not have a regulatory regime that allows them to do so.

Of particular interest to me is the glaring need for a new focus on energy system resilience. The changing resource mix, recent severe weather events, and the dynamic nature of grid technologies—including changes on the demand side—are bringing grid resilience to a new, more prominent place in the discussion. Specifically, as we keep one eye on day to day reliability as well as resource adequacy, we must also begin to incorporate resilience into the discussion. Weather events such as the Polar Vortex or Hurricanes Harvey and Irma are stark reminders of the need to have a bulk power system that can withstand stresses and recover from them quickly.

As Secretary Perry has noted on numerous occasions, America is blessed to have the incredible energy systems and resources we have today. The millions of dedicated men and women who work in the electricity industry and supporting functions do a tremendous job, and they should be recognized for their dedication and success.

Transmission Regulatory Reform

Over the last several years DOE has led Federal government actions to improve the siting and permitting of electric transmission infrastructure development. Our efforts include creating a process by which DOE acts as lead for coordination of timely agency review of electric transmission projects requiring multiple Federal authorizations as required by section 216(h) of the Federal Power Act.

DOE's Integrated, Interagency Pre-application (IIP) Process Final Rule went into effect on November 23, 2016. The IIP is intended to improve early project planning through a simplified two-meeting process that is voluntary with timing driven by the transmission developer(s). An important strength of the process is that other agencies (Federal, State/Local, Tribal) with authorizations or permit decisions for a proposed transmission project would be invited to participate. This provides a transmission developer an early opportunity to share information about its proposed project with all agencies at one time, thereby reducing redundancy in planning activities on the part of the transmission developer.

The IIP also helps in ensuring that potential issues are identified by permitting agencies before a project proponent files an accurate and complete application, thereby streamlining later review and permitting processes. DOE Transmission Permitting and Technical Assistance (TPTA) intends to bolster the IIP process through guidance and policy in such a way to make the process more appealing to transmission developers and supportive of the goals of effectively and efficiently meeting the reliability and resiliency needs of the nation's electric grid.

Research Innovation

Working with the national laboratories and industry partners, DOE has focused on delivering new technologies for operating, planning, monitoring and protecting the grid. The Department announced Tuesday up to $50 million to national laboratory led teams focused on resiliency and cybersecurity. All states and regions face challenges as the grid evolves and these projects are helping move innovative research into practical and timely utilization by the electricity sector, including cooperatives, municipalities and investor owned utilities from all regions of the country.

The awards include:

Grid Resilience and Intelligence Platform – GRIP: The objective of this project 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, and controlling DERs.

Resilient Alaskan Distribution System Improvements using Automation, Network Analysis, Control, and Energy Storage (RADIANCE): The objective of this project is to enhance the resilience methods for distribution grids under harsh weather, cyber-threats, and dynamic grid conditions using multiple networked microgrids, energy storage, and early-stage grid technologies.

CleanStart-DERMS: The objective of this project is to validate and demonstrate at scale a DER-driven mitigation, blackstart and restoration strategy for distribution feeders with integration of applied robust control, communications and analytics layer, and coordinated hierarchical solution.

SASS-E (Safe & Secure Autonomous Scanning Solution for Energy Delivery Systems): Develop scanning methodologies, models, and architectures to transform a network vulnerability scanner widely deployed in the IT space, into a scanner that can be used in the operational space.

Energy Delivery Systems with Verifiable Trustworthiness: Provide a tool to verify the integrity of firmware used in energy delivery system devices, without taking the equipment offline.

DarkNet: Define the requirements for a secure energy delivery control system network that is independent of the public internet, and uses existing but currently unused optical fiber, so-called "dark fiber".

Conclusion

Secretary Perry and our DOE team look forward to a thoughtful conversation focused on the reliability, affordability, and resilience of the electricity system. I began by noting that the electricity sector is in a period of major change, that the pace of change may be accelerating, and that this process of change may continue indefinitely. The implications are profound: we only have one electric grid, and we are more dependent on it than ever for our economic well-being and national security. The grid must function, and it must function well, in that it must meet a number of competing technical and economic requirements, simultaneously and continuously. This means that we must learn, collectively, to manage this process of change.

To me, managing this process of change means:

- We must think about the grid holistically, as a single, interactive set of policies and components that have to be designed to operate synergistically in order to meet a diverse set of design requirements simultaneously.
- We need to monitor the grid's characteristics and performance routinely and systematically, according to key parameters, so that we will be able to recognize significant change when we see it and respond with appropriate market and policy mechanisms.
- We need to develop more systematic ways of looking ahead – that is, we need periodically to identify a range of future directions in which the grid could evolve, and assess their implications, so that if our current data tells us that the grid is trending in one direction or another, we will know how to respond effectively.
- Finally, managing change will require new processes and practices for collaboration and coordination across the electricity community, including partnerships with the private sector, in order to achieve our shared objectives.

Thank you, and I look forward to your questions.

Mr. OLSON. Thank you, Ms. Hoffman.

The Chair now calls upon Mr. Gerry Cauley. He is the president and CEO of the North American Electric Reliability Corporation.

You have 5 minutes, sir.

STATEMENT OF GERRY W. CAULEY

Mr. CAULEY. Thank you, Vice Chairman Olson, and Ranking Member Rush, and the members of the subcommittee. Thank you for conducting this timely hearing as we face a period of rapid change in the electricity industry. Driven by an abundance of natural gas, public policy, advances in technology, market forces, and customer preferences, this transition is altering our understanding of base load power and how generating resources are dispatched.

As the Electric Reliability Organization, NERC is focused on the emerging challenges presented by the Nation's rapidly changing resource mix. With appropriate policies, careful planning, and strong actions, I am confident the electricity sector will continue to accommodate these changes and enhance reliability and resilience. Even with the changes already under way, the bulk power system remains highly reliable and resilient and shows improved performance each year. This record demonstrates the strong commitment to reliability by all stakeholders. But reliability requires constant vigilance now more than ever.

Let me take a moment to describe NERC's role in identifying emerging reliability risks before they become bigger problems. Each year, we conduct a long-term reliability assessment that looks at the reliability of a system 10 years out. Annually, we also provide a state-of-reliability report that looks at the grid performance over the previous year. We conduct special assessments focused on challenges, such as the integration of renewables and distributed energy resources and the increased reliance on natural gas infrastructure.

We analyze system events, such as the unexpected loss of power from solar farms in California during the Blue Cut fire in August of 2016.

Over the past 6 years, the 50 largest events impacting the grid were caused by severe weather, leaving NERC to focus on resilience as a priority going forward. Through our studies, we are able to provide risk-informed recommendations to continuously improve reliability and resilience.

Next, I would like to turn to how the change in resource mix will affect reliability. The grid is highly interconnected and depends on having the right combination of resources and transmission. It is important to maintain a continuous supply of essential reliability services in the right locations on the system. As just a few examples, these include inertia, frequency response, voltage control, stability, and ramping to meet changes in demand and variability of renewable resources. Conventional base load units with relatively high availability rates and onsite fuel have historically provided these essential reliability services. When these units retire, new resources coming on to the system must replace these essential reliability services that are being lost. As more resources move behind the meter, it is also increasingly important for the system operators to have visibility into those resources. As our power supply becomes increasingly dependent on natural gas, we must ensure this just-in-time fuel is as reliable and secure as the power plants that need the fuel to operate.

Many issues and recommendations identified by NERC are reflected in DOE's staff report on electricity markets and reliability. Both NERC and the DOE study agree on the need to maintain essential reliability services, promote resilience, coordinate gas/electric issues, and collaborate with Canada and Mexico on reliability.

More specifically, I would like to highlight several recommendations of my own. FERC, States, and markets should review the economic and market factors driving base load generation into early retirements and provide tangible incentives for maintaining a diverse and resilient resource mix. All new resources should have the capability to support essential reliability services. Markets should explicitly value and price capacity, essential reliability services, and enhanced resilience through fuel diversity. Policymakers should evaluate alternatives for ensuring adequate capacity of gas pipelines and storage to meet electricity production needs during extreme conditions and ensure that gas infrastructure is as secure from cybersecurity and physical security threats as the grid that it supplies.

Markets should incent and, as needed, require all resources, including demand response, ensure those resources will perform in both normal and extreme conditions.

And finally, policymakers should seek alternatives to streamline siting and permitting of transmission.

To address the challenges and benefits of a more diverse resource mix, industry stakeholders and policymakers must understand and plan for the risks of our rapidly changing resource fleet. NERC plays a critical role as an objective and independent expert organization, and I appreciate the opportunity to share our thoughts and expertise with you here today.

Thank you.

[The prepared statement of Mr. Cauley follows:]

"Powering America: Defining Reliability in a Transforming Electricity Industry"

September 14, 2017

Before the Subcommittee on Energy
House Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC

Testimony of Gerry W. Cauley
President and Chief Executive Officer
North American Electric Reliability Corporation

SUMMARY

The electricity sector is undergoing significant change that is unprecedented for both its transformational nature and rapid pace, presenting new challenges and opportunities for reliability. With appropriate insight, careful planning, and support, the electricity sector can continue to navigate these changes in a manner that results in enhanced reliability and resilience. Even with all the changes underway, the bulk power system (BPS) remains highly reliable and resilient, showing improved reliable performance year over year.

About NERC and NERC's Role in Evaluating BPS Reliability and Security
The North American Electric Reliability Corporation (NERC) is a private non-profit corporation certified by the Federal Energy Regulatory Commission (FERC) as the Electric Reliability Organization (ERO) for the United States. NERC reliability assessments evaluate the performance of the BPS, identify reliability trends, anticipate challenges, and provide a technical platform for important policy discussions. NERC's analyses of system disturbances also provide critical insights.

Reliability and How the Changing Resource Mix Affects It
Adequate capacity must be maintained to serve firm load. It is important to understand and plan for the different operating characteristics of variable resources. These resources also contribute to reliability and resilience.

Changes occurring in the generation resource mix and new technologies are altering the operational characteristics of the grid and will challenge system planners and operators. Conventional baseload generation has important reliability attributes. Reliability of the electric grid depends upon the operating characteristics of replacement resources.

Learning from System Events – A Case Study
NERC's analysis of a frequency excursion event in California revealed that protection settings on certain solar facility inverters caused erroneous tripping. This led to a recommendation to adjust the inverter settings. It is an example of NERC's focus on identifying small, isolated events that could pose greater threats to reliability.

DOE Staff Report
The Department of Energy's (DOE) recent staff report cites NERC's assessments. Many topics, findings, and recommendations in the staff report are consistent with NERC's work.

The Changing Resource Mix: NERC Recommendations
Baseload Retirements – Regulators and market operators should keep in mind the changing reliability aspects of the grid when considering resource needs, adequacy requirements, distribution-level interconnection requirements, and long-term resiliency.

Essential Reliability Services – All new resources should have the capability to support voltage and frequency. Policies and market mechanisms may not provide enough incentive or clarity.

Natural Gas Regulation and Markets – Regulators and policy makers should evaluate the natural gas regulatory framework for transportation priority and construction. Market operators should also evaluate whether market rules should be revised to provide assurances that generators will perform in normal and extreme circumstances.

Introduction

Good morning Chairman Upton, Ranking Member Rush, members of the subcommittee and fellow panelists. I am Gerry Cauley, President and Chief Executive Officer of NERC. On behalf of NERC, I appreciate the committee's focus on reliability in a transitioning electricity industry.

The electricity sector is undergoing significant change that is unprecedented for both its transformational nature and rapid pace. Such extraordinary change presents new challenges and opportunities for reliability. Dramatic advances in technology, customer preferences, public policy, and market forces are altering the generation resource mix and challenging the conventional understanding of baseload power, traditionally provided by large generating units with low maintenance and forced outage rates. These changes also are pressuring regulatory policy, sometimes blurring the lines between federal and state jurisdiction. Within the North American continent, cross-border electricity trade between the United States, Canada, and Mexico requires enhanced cooperation. Security is yet another major challenge as the threat landscape becomes ever more complicated with the rise of malicious actors seeking to attack critical infrastructure through cyber warfare.

With appropriate insight, careful planning, and support, I am confident the electricity sector will continue to navigate these changes in a manner that results in enhanced reliability and resilience.[1] Even with all the changes underway, the BPS remains highly reliable and resilient, showing improved reliable performance year over year.[2] This record demonstrates the strong commitment to reliability by industry and all stakeholders, and the effectiveness of the model adopted by this committee in the Energy Policy Act of 2005.

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[1] The National Infrastructure Advisory Council provides this definition of "resilience" – "Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event." This definition is cited in a NERC report, "Severe Impact Resilience: Considerations and Recommendations" (May 9, 2012).

[2] *See* "State of Reliability 2017" (NERC, June 2017).

While these accomplishments are highly significant, I have learned from more than 35 years of experience that reliability requires constant vigilance. This is more true now than at any point in history. Working with FERC, DOE, industry, and numerous other stakeholders, NERC remains focused on identifying, assessing, and responding to reliability risks posed by change in the electricity sector. I am pleased to discuss NERC's work to address this critical priority.

About NERC and NERC's Role in Evaluating BPS Reliability and Security

NERC is a private non-profit corporation that was founded in 1968 to develop voluntary operating and planning standards for the users, owners and operators of the North American BPS. Pursuant to Section 215 of the Federal Power Act (FPA) (16 U.S.C. §824o) and the criteria included in Order No. 672 for designating an ERO, FERC certified NERC as the ERO for the United States on July 20, 2006. On March 16, 2007, FERC issued Order No. 693 which approved the initial set of reliability and security standards. These reliability standards became mandatory in the United States on June 18, 2007.

NERC develops and enforces reliability and security standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC performs a critical role in real-time situational awareness and information sharing to protect the electricity industry's critical infrastructure against threats to the BPS. NERC's responsibility spans the continental United States, Canada, and Mexico. Our jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

Section 215(g) of the FPA requires NERC to assess the reliability and adequacy of the BPS. NERC reliability assessments evaluate the performance of the BPS, identify reliability trends, anticipate challenges, and provide a technical platform for important policy discussions. Each year, NERC assesses the overall reliability, adequacy, and associated risks that could impact the upcoming summer and winter seasons, and the long-term, 10-year period. As emerging risks and potential impacts to reliability are identified, NERC also conducts special assessments on focused reliability topics that provide a similar technical framework and insights.

By identifying and quantifying emerging reliability and security issues, we are able to provide risk-informed recommendations and support a learning environment for industry to pursue improved reliability performance. These recommendations, along with the associated technical analysis, provide the basis for actionable enhancements to resource and transmission planning methods, planning and operating guidelines, security, as well as NERC reliability and security standards. In short, NERC's objective assessments provide critical insights necessary for assuring reliability and security of a rapidly changing electricity sector.

Reliability and How the Changing Resource Mix Affects It

The North American BPS is designed to be highly reliable, robust, and resilient. The system is interconnected, and the integrated networks work together to maintain reliability through both wide-area interregional planning and coordinated system operations. The adequacy of the system is maintained by having the right combination and amount of resources and transmission to deal with unexpected facility outages or extreme weather events. Operating reliability is maintained in real-time through highly coordinated operator actions across many operating companies.[3] The system is also planned as many as 15 years in advance through highly detailed, complex, and data-intensive power system simulations.

The BPS resource mix is changing in fundamental ways. As some conventional baseload generation from coal and nuclear retires, variable energy resources – especially wind and solar – are rapidly expanding and capturing the majority share of new capacity additions. The balancing resource tends to be natural gas. It is essential to understand the implications of these trends in order to maintain reliability.

The changing resource mix can fundamentally impact reliability in two major ways:

[3] NERC defines "reliable operation" in the following manner: "Operating the elements of the [Bulk-Power System] within equipment and electric system thermal, voltage, and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements. *See* "Glossary of Terms Used in NERC Reliability Standards."

- Resource Adequacy – A balancing authority responsible for managing the balance of demand and resources through unit commitment and forecasting must maintain sufficient capacity at all times to serve firm load.

- Planning for Variable Resources – It is important to understand and plan for the different operating characteristics of variable resources. These include planning for adequate essential reliability services, managing faster fault-clearing times, reduced oscillation dampening, and unexpected inverter action. Variable resources significantly diversify the generation portfolio and can contribute to reliability and resilience in important ways.

The rapid changes occurring in the generation resource mix and new technologies are altering the operational characteristics of the grid and will challenge system planners and operators. More specifically:

- Impact of Retirements – Conventional baseload electric generating units, such as coal and nuclear plants, provide frequency support services as a function of their large spinning generators and governor-control settings along with reactive support for voltage control. Power system operators use these services to plan and operate reliably under a variety of system conditions. These units also have relatively high availability rates and on-site fuel.

- Replacement Resource Capability and Characteristics – As the generation resource mix evolves, the reliability of the electric grid depends upon the operating characteristics of the replacement resources. Natural gas-fired units, variable generation, storage, and other resources can provide reliability services. However, as a practical matter, operating characteristics, economics, and market rules can affect whether these resources are equipped and available to provide reliability services. New generator and load resources must maintain the balance between load and generation, especially during ramping periods. In addition, in some areas, substantial amounts of generation is now being added "behind the meter" (e.g., rooftop solar). It will become increasingly important for system operators to have visibility into these resources.

Learning from System Events – A Case Study

NERC also gains considerable insight into reliability risk through analysis of system disturbances. An event last year in California is a recent example that is directly related to avoiding risk from the changing resource mix. It shows how NERC identifies and addresses a small problem today in order to avoid a potentially larger, more significant problem in the future.

On August 16, 2016, smoke from the Blue Cut wildfire in San Luis Obispo County, California, resulted in the tripping of two 500 kV lines in the active fire area. There was a noticeable frequency excursion with Peak Reliability reporting the loss of more than 1,000 MW across multiple renewable resources following these line outages. California ISO, Southern California Edison, and Peak Reliability confirmed that no conventional generators tripped, and that the near instantaneous loss of resources were all utility-scale renewables, primarily solar.

While the event did not rise to the level of a major disturbance by NERC criteria, the occurrence was significant and unusual because it is the first known major loss of renewable resources due to a transmission system disturbance. Subsequent analysis of this event determined that the protection settings on the solar facility inverters caused erroneous tripping. In response, manufacturers of inverters that experienced this type of tripping during the event have recommended a change in their inverter settings to avoid this issue. This recommendation calls for the addition of a time delay to their frequency tripping settings. This will allow the inverter to "ride through" the transient/distorted waveform period without tripping.

NERC has taken two additional actions in response to the Blue Cut wildfire event. In June, we published a report prepared by a joint task force of NERC, the Western Electricity Coordinating Council, FERC, and involved entities to analyze this disturbance, determine the causes, and develop key findings and recommendations.[4] We also issued a public Level II NERC Alert to industry. This alert – which requires a response – provides specific actions that NERC registered entities should consider taking to address this particular issue. NERC's work following this event is an example of detecting "faint signals" – identifying small, isolated events that could pose greater threats to reliability.

DOE Staff Report

DOE's recent study, "Staff Report to the Secretary on Electricity Markets and Reliability," cites NERC's assessments throughout the reliability and resilience chapter. We appreciate DOE's focus on reliability and resiliency as well as recognition of NERC's long time work on these issues. Many topics, findings, and recommendations in the staff report are consistent with NERC's work.

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[4] *See* "1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report" (NERC, June 2017).

Specifically, as conventional resources retire, essential reliability services much be maintained. Voltage control, frequency support and ramping capability must be provided based on the configuration and needs of the system. Reliable operation of the grid depends upon these characteristics.

As an enhanced yardstick of reliability, resilience is reflected throughout NERC's programs. For instance, NERC's definition of "adequate level of reliability" includes a performance outcome providing for expeditious recovery from major system disturbances. NERC has a family of emergency preparedness and operations standards covering such topics as blackstart capability, system restoration coordination, and geomagnetic disturbance operations.[5] NERC published a report on severe impact resilience[6] and has collaborated with FERC and regional entities on industry's response and recovery plans.[7]

The combination of growth in natural gas demand within the electricity sector and its changing status among the gas-consuming sectors continues to increase significantly the interdependencies between the natural gas and electricity industries. Real-time delivery of natural gas through a network of pipelines and bulk gas storage is critical to support electric generators. It is also important to evaluate the impacts of a loss of major pipeline infrastructure. NERC has examined natural gas and electricity interdependencies in detail and has developed recommendations for the power industry.[8]

DOE's staff report also recommends expanded cooperation on grid reliability with Canada and Mexico. Cross-border interconnections require shared priorities for reliability and security throughout North America. Consistent with a set of principles signed in 2005 by DOE and Canadian provincial and federal counterparts, NERC is structured as an international organization. Under memoranda of understanding or other agreements with authorities in each province, NERC standards are adopted and enforced under provincial laws. In addition to strong

[5] *See* Emergency Preparedness and Operations Standards.
[6] *See* "Severe Impact Resilience: Considerations and Recommendations" (NERC, 2012).
[7] *See* "FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans" (2016) and "Further Joint Study Report: Planning Restoration Absent SCADA or EMS" (2017).
[8] *See* "Accommodating an Increased Dependence on Natural Gas for Electric Power" (NERC, 2013).

collaboration with Canadian provincial and federal government stakeholders, NERC works extensively with Canadian industry on reliability and security matters, and has partnered with DOE on numerous relevant efforts. In March, NERC signed a memorandum of understanding (MOU) with government authorities in Mexico to advance shared reliability priorities as Mexico implements comprehensive electricity reforms. NERC expects that Mexico will become a full participant, on par with the United States and Canada, as the implementation of the MOU is fully realized over the next several years.

The Changing Resource Mix: NERC Recommendations

As detailed above, NERC continually assesses the reliability of the BPS to evaluate system performance, identify trends, assist policymakers, and promote a learning environment. NERC's event analysis group also supports these objectives through detailed examination of system disturbances. Based upon this recent work, NERC has formulated recommendations related to the changing resource mix. For additional findings and recommendations, the appendix includes references to recent NERC assessments.

Baseload Retirements – State regulators and market operators should keep in mind the changing reliability aspects of the grid when considering resource needs, adequacy requirements, distribution-level interconnection requirements, and long-term resiliency. States and FERC should continue review of the economic and policy issues impacting fuel secure baseload generation in order to plan for and identify reliability implications of these retirements. States and FERC should ensure that required reliability characteristics are considered when identifying future reliability and capacity needs.

Essential Reliability Services – All new resources should have the capability to support voltage and frequency. Some variable energy resources and storage technologies can contribute to essential reliability services. Policies and market mechanisms may not provide enough incentive or clarity to ensure these services are maintained across the system. Regional transmission organizations and independent system operators and FERC have taken steps in this direction, which should continue.

Natural Gas Regulation and Markets – Regulators and policy makers should evaluate whether the natural gas regulatory framework for transportation priority and construction is compatible with the requirements of the changing BPS. Market operators should also evaluate whether market rules should be revised to provide assurances that generators will perform in normal and extreme circumstances.

Conclusion

The transitioning electricity sector poses challenges and opportunities for reliability. Retirements of baseload generation and the addition of greater variable resources are altering the operating characteristics of the grid. A significant influx of natural gas generation raises unique considerations for fuel delivery and dependence. To address the challenges and capitalize upon the benefits of a more diverse resource mix, industry stakeholders and policymakers must understand and plan for the implications of the ongoing evolution. With a focus on these challenges, the grid can become even more reliable and resilient. Throughout this transition, NERC plays a critical role in identifying, assessing, and addressing risks to help navigate the transition reliably. The Subcommittee is asking highly salient questions that are central to the nation's energy future and prosperity. I appreciate the opportunity to share NERC's perspective and expertise.

APPENDIX

This appendix includes summaries of recent NERC assessments which provide additional findings and recommendations.

Distributed Energy Resources: Connection, Modeling, and Reliability Considerations (February 2017)
Increasing amounts of distributed energy resources can change how the distribution system interacts with the BPS and will transform the distribution system into an active source for energy and essential reliability services. Attention must be paid to potential reliability impacts, the time frame required to address reliability concerns, coordination of essential reliability services and system protection considerations for both the transmission and distribution system, and the growing importance of information sharing across the transmission-distribution interface.

2016 Long-Term Reliability Assessment (December 2016)
NERC prepares seasonal and long-term assessments to examine current and future adequacy and operational reliability of the North American BPS. NERC's primary objective with this assessment is to assess resource and transmission adequacy across the NERC footprint, and to assess emerging issues that have an impact on BPS reliability over the next ten years.

A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability, NERC (October 2014)
Conventional generation with large rotating mass (steam, hydro, and combustion turbine technologies) provide necessary operating characteristics, defined as essential reliability services, needed to operate the North American electric grid reliably. Essential reliability services represent a necessary and critical part of the fundamental reliability functions that are vital to ensuring reliability. They are key services and attributes that are needed to maintain operating reliability—primarily voltage and frequency support. Many of these services and attributes are provided by baseload conventional generating plants; however, as the resource mix changes, essential reliability services must be maintained.

Accommodating an Increased Dependence on Natural Gas for Electric Power (May 2013)
The combination of growth in natural gas demand within the electricity sector and its changing status among the gas-consuming sectors continues to significantly increase the interdependencies between the gas and electricity industries. As a result, the interface between the two industries has become the focus of industry discussions and policy considerations. In its effort to maintain and improve the reliability of the North American BPS, NERC examined this issue in detail and developed recommendations for the power industry. These recommendations will help improve existing coordination between the gas and electricity sectors and facilitate the reliable operation of the two industries.

Mr. OLSON. Thank you, Mr. Cauley.

The Chair now calls upon the ranking member of the full committee, Mr. Pallone, for 5 minutes.

Mr. PALLONE. Mr. Chairman, I will just submit my statement for the record because my understanding is that there are going to be votes. And I will just submit it for the record. I will ask unanimous consent.

Mr. OLSON. Without objection, so ordered.

[The prepared statement of Mr. Pallone follows:]

PREPARED STATEMENT OF HON. FRANK PALLONE, JR.

Mr. Chairman, thank you for holding today's hearing to explore how we define electric reliability in today's world. This is the first of two hearings that we will be holding on electric reliability as part of our bipartisan hearings on the electric sector. I appreciate the way the chairmen and the Republican committee staff have worked with us and our staff to move this series forward in a very constructive way.

I want to start by welcoming Chairman Chatterjee: we appreciate your willingness to come before us so soon after taking the reins at FERC. I also appreciate the flexibility of Mr. Cauley and Ms. Hoffman in making themselves available today. I'm particularly pleased to have Ms. Hoffman, not just because of her long service and deep knowledge, but also because her presence represents the first time in eight months that the Trump Administration has provided this subcommittee with a witness. That is unique and unfortunate, and I hope that Ms. Hoffman's presence today marks a change for the better.

I firmly believe that it is time to start looking at reliability in new and different ways. If there is one thing we have learned in the past two weeks -a period that has left nearly 8 million without power-it is that climate change is having devastating effects on our communities and we must modernize our electricity system to make it more resilient. A recent study of FEMA disaster declaration records shows that over the last 20 years four times as many counties were hit by disaster-scale hurricanes, storms and floods than during the two decades before that period.

While the regulatory standards for what constitutes reliability seem not to have changed much in the past few decades, the technology by which we can achieve reliability certainly has transformed dramatically. In the past, things like redundant transmission lines may have been the only way to guarantee reliability, but that's hardly the case today.

We can now make our system more reliable and more resilient by incorporating technologies to manage demand and by generating and storing power closer to where it is consumed, through use of batteries and distributed generation resources including renewables like rooftop solar. These assets can be connected by microgrids and isolated from the transmission and main distribution system.

While climate change is producing stronger storms more frequently that can damage every part of the grid, in most storms it is the distribution system that is the most vulnerable part of the grid, and not the larger transmission system or generating assets. In a grid characterized by large, centralized power production, if the distribution lines are down, it doesn't matter how many transmission lines we have because the power can't get to the consumer. While we are awaiting an assessment of the impact of Hurricanes Irma and Harvey, I know that in my area, Superstorm Sandy showed us that centralized power, carried by lines over great distances, does not guarantee reliability or a resilient grid. After its experience with Sandy, New Jersey's largest utility said, "reliability remains fundamental but is no longer enough now that extreme storms have become increasingly common." This is an important distinction that is playing out in the wake of Hurricanes Harvey and Irma.

To encourage the innovation we need to make our grid more reliable and resilient, we also need to reexamine the way we calculate rates and how utilities make money. In many ways, traditional rate setting encourages utilities to make money just by building new transmission lines. Those new lines could also have the effect of locking in a market for older, fossil fuel generation that accelerates climate change while crowding out cleaner and less expensive options for generating power and ensuring reliability. Utilities should be able to make money, but I'm concerned that the old rate-making model may encourage utilities to continue building too many of yesterday's capital facilities that do not maximize reliability and resiliency when better options are available today.

As our committee discusses the grid, we should carefully reexamine the old approaches to reliability, resiliency and ratemaking to seriously consider whether our long-term interests are better served by charting a new course.

Again, thank you for holding this hearing, and I look forward to hearing from our distinguished witnesses.

Mr. OLSON. And I thank you all for your testimony.

And now we begin the question-and-answer portion of this hearing.

I will begin with a question and recognize myself for 5 minutes.

Hurricane Harvey hit my home State twice, but we never lost power at my home in Sugar Land. Some people are still without power in Texas, Louisiana. A lot of people in Florida don't have power because of Hurricane Irma. Without power, there is much greater damage: mold, even death, as we saw in Florida.

My first question is for you, Ms. Hoffman. I know that DOE has been very busy assisting with Hurricane Harvey and Hurricane Irma recovery efforts. We applaud that. But can you talk a second about the programs DOE has in its place not only to recover but to also prepare for storm events in the future?

Ms. HOFFMAN. Yes, Vice Chairman. Thank you very much for the question. The Department has been actively engaged with utilities through our R&D program to look at advanced technologies that we have helped support the industry, test out on the grid, such as automated switching, rerouting of power, the ability for utilities to do outage management, to really take a look at and be proactive in the response characteristics for identifying where the outages are. If you remember, customers usually have to call the utility to let them know their power is out. Now the utilities have been able to automate a lot of those systems.

In addition, we have been working with the States and the regions to really exercise and understand—each hurricane is different. The damage is significant. And we have been helping the States prepare for this.

Mr. OLSON. Well, thank you.

What has been the role of the ESCC, the electricity subsector coordinating council, during hurricane preparations and response?

Ms. HOFFMAN. The Electric Sector Coordinating Council has had a significant role. It is the focal point of coordination between the Federal Government and CEOs, the leaders in the electric utility industry. This allows for continuity of message and activities, so that we are all on the same page of what the priorities are and what the activities and the needs are by industry to the highest level of the Federal Government, as well as industry, in supporting a coordinated, but most importantly an effective, restoration process.

Mr. OLSON. And back home, the people say it is working very well. Glad to hear it is working well on your side.

My final question, Ms. Hoffman, is, a few months ago, we passed a bill out of this committee, H.R. 3050, that helps improve State energy assurance planning. How does an energy assurance plan help a State deal with extreme weather events, like Harvey, Irma, and more hurricanes?

Ms. HOFFMAN. So energy assurance planning is an important activity that the States undertake to really take a hard look at scenarios of potential events that could impact their State but also look at how this affects the energy resources. So it allows us to look at contingency, and it really thinks about, how do we build in resilience in partnership with the States?

Mr. OLSON. Thank you.

My last question is for you, Chairman Chatterjee. In order to have a reliable electricity system, we must protect our grid from cybersecurity threats. For example, I understand you participate in the grid exercises. How do these types of exercises make the electricity system more reliable? And what else are you doing in terms of cybersecurity?

Mr. CHATTERJEE. Thank you for the question, Vice Chairman. The Commission and I myself take cybersecurity and protecting our grid from cyber attacks very seriously. FERC is focused on ensuring reliability in the face of some of the cyber challenges that we have. We also have an Office of Energy Infrastructure Security that is trying to stay ahead of potential threats to the grid and participate in some of these activities. There is no question that threats to our system of electricity generation distribution, whether from hurricanes or from cyber attacks, are of the utmost concern to the Commission, and I will continue to work with you all and my colleagues to ensure the safety of our grid.

Mr. OLSON. Thank you. That is all my questions.

The Chair now calls upon the gentleman from Illinois, the ranking member of the subcommittee, Mr. Rush, for 5 minutes.

Mr. RUSH. I want to thank you, Mr. Chairman.

I want to ask all three of you the first question. In your professional opinion, do you anticipate that climate change will continue to play a significant role in threatening the Nation's energy infrastructure due to more frequently occurring superstorms, hurricanes, and other natural disasters, including heat waves, droughts, fires, and floods? Each one of you, I would like for you to respond, beginning with you, Mr. Chatterjee.

Mr. CHATTERJEE. I think it is important, as we confront these storms and the impacts that they have had on our grid, that we ensure that, as our grid transforms for the future, that we ensure that we can bounce back from these types of events and have a really reliable and resilient grid.

As the vice chairman mentioned, when the power goes out, people really suffer. I was on an ESCC call with Secretary Perry in which he talked about the fact, after a couple of days, you are hot, you are tired, you are wet, and if you don't have power, you start to get upset. And it is important that, in response to these weather events and challenges, that we have a reliable and resilient grid. And I think the role of the Commission will be to look that, as we are in this transformational period, that we ensure that the reliability, the world class, second-to-none reliability that our country has enjoyed can be maintained going forward.

Mr. RUSH. Ms. Hoffman.

Ms. HOFFMAN. I would echo the chairman's comments, that I believe it is the duty and responsibility of the electric industry to be forward leaning and to think about different scenarios and events that will happen, build it off of the knowledge base we have experienced, and look about how do we build in resilience moving forward; what can we do to our infrastructure to continue to support an effective restoration process, to getting the lights on as quickly as possible?

Mr. CAULEY. So, understanding climate change is outside of my expertise or my organization's expertise, but we do see, in recent years, in my time as 8 years as CEO, it seems as we are seeing an increase in the magnitude and severity of events, flooding, and storms. And it is something, as the other two panelists mentioned, I think we have to think about in the design of our systems and our preparations to think about, how do we prepare for more extremes than we have seen historically?

Mr. RUSH. Each of you, do you feel as though there is a sense of urgency that is apparent in the Congress or in both administrations or in the administration, be it Republican or Democrat? Is there a sense of urgency about greater reliability in the event of severe weather challenges?

Mr. CHATTERJEE. I laid out in my opening remarks some of the steps that the Federal Energy Regulatory Commission took immediately to respond to the devastation that was wrought by Hurricanes Harvey and Irma. And I can say that we most certainly view the reliability and resilience of our grid with the utmost sense of urgency.

Ms. HOFFMAN. With two Cat 4 hurricanes impacting the mainland of the United States, there is definitely a sense of urgency. Secretary Perry, former Governor of Texas, recognizes the devastation to life and the economic development and human safety. So it is definitely forefront on our radar.

Mr. CAULEY. I sense that there has been a strong focus on resilience of the grid through both of the most recent administrations. And we are working hard on that.

And the reason is, in my opening remarks, I mentioned the 50 most significant events we have seen in the U.S. in the last 5 years are all weather related. So it says we can invest more in hardening and protecting our system.

Florida Power & Light, in Irma, had recently invested $3 billion on hardening using concrete poles, steel poles, elevating substations, and the equipment that was hardened performed significantly better than the equipment that had not been hardened yet. So it was a good demonstration.

Mr. RUSH. I have just a short period of time now. I want to ask Chairman Chatterjee and Mr. Cauley, according to the cybersecurity firm Symantec Corporation, there has been an uptick in activity by a group of hackers code-named Dragonfly 2.0 within our domestic energy networks after years of seemingly being inactive. Are FERC and NERC monitoring this activity? And are you both confident that you have the tools to address this issue in order to prevent this group from sabotaging our electric infrastructure?

Mr. CHATTERJEE. Thank you for the question, Congressman. We are aware of the Symantec report and have been coordinating closely with other Federal agencies, as well as the NERC ISAC, and industry to assess and address this matter as appropriate. If it would be helpful to members of the subcommittee, we could seek to coordinate with other agencies to provide additional information in a nonpublic setting.

Mr. CAULEY. Dragonfly has been around for 3 or 4 years. We have been aware of it and communicating with the industry. This new reincarnation of Dragonfly 2 is recent. And it has characteristics that would make it operative within control systems, within substations, and so on. So it is of interest. The instances that we have seen have not gotten into those systems. They were picked up through traffic between the utility systems and information going offshore. So it has not done any harm. It has not infiltrated the systems yet. But it is there, and it is active.

Mr. RUSH. I yield back, Mr. Chairman.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon the gentleman from Texas, the vice chairman, Joe Barton.

Mr. BARTON.

I ask all Members, please adhere to the 5-minute time. Please, please, please. We have got so many people and questions that we are running out of time.

Chairman Barton, you are up.

Mr. BARTON. Because of what you just said, Mr. Chairman, I am going to ask one question, and then I will yield to anybody on my side.

Many, many States are adopting renewable portfolio standards, and some of them are fairly aggressive. They want to have at least 50 percent—and there might be even a few States that are above that—of their electricity generation with renewables. My question, I guess, would be to Mr. Cauley, who is head of NERC, is it possible to meet the same reliability standards if you go to a generation system that is predominantly renewable?

Mr. CAULEY. I think, from what we are seeing, it is technically feasible, but there are a lot of reliability challenges. I gave the example of August a year ago, in California, there was a wildfire that caused a transmission wire to trip. When 1,200 megawatts of solar panels saw that, they thought it was the system collapsing, so they all shut down at the worst time. And so there has to be coordination.

Wind and solar do not inherently come with the controls to provide frequency response, voltage response. They just want to put out megawatts; they want to put out power. But, technically, we have been working with the vendors to show them some of those weaknesses and things that need to be done.

Mr. BARTON. In the short term, the answer is no; it is not possible. But in the long term, with some battery research and other things, it is, perhaps, possible?

Mr. CAULEY. Well, I think the technology is there today. It just requires a lot of coordination.

Mr. BARTON. I would yield to Mr. Shimkus.

Mr. SHIMKUS. Thank you, Joe.

And because it is on the same line, this is to Mr. Chatterjee.

We had the qualifying facilities, the PURPA hearing last week or 2 weeks ago. So just a couple questions that kind of segue right into what Joe was saying. One is: Some of the electricity markets talked about how that there may be an opportunity to curtail the QFs to make sure they continue to keep the reliability of the grid. You have any comments object that?

Mr. CHATTERJEE. I want to be careful, Congressman, as we have———

Mr. SHIMKUS. I don't want you to be careful.

Mr. CHATTERJEE. As you know, Congress enacted PURPA in 1978. I think we have heard from numerous stakeholders that there is an interest in reviewing potential reforms. Significant changes to PURPA would require congressional action. There are steps that FERC can take with respect to PURPA implementation on minor issues. And we held a technical conference on this. But I think we———

Mr. SHIMKUS. Let me just go at it this way: You understand that there is a concern that maybe some of these projects are located for the benefit of the investors over the grid reliability?

Mr. CHATTERJEE. It is certainly something that we are looking at.

Mr. SHIMKUS. And let me follow up with this: The one-mile debate, hopefully you listened or saw part of the testimony———

Mr. CHATTERJEE. Yes, sir.

Mr. SHIMKUS [continuing]. Where some of these qualifying facilities were able to break down the parcels to game the system. Is that part of your review and discussion?

Mr. CHATTERJEE. It absolutely is. And it is something that we would review to see whether that is something that the Commission could handle within its purview, potentially not require a statutory change from Congress.

Mr. SHIMKUS. Great. Thank you.

And I yield back to Chairman Barton.

Mr. BARTON. I would be happy to yield to any other Member.

If not, Mr. Chairman, I yield back to you.

Mr. OLSON. The gentleman yields back.

The Chair calls upon the ranking member of the full committee, Mr. Pallone from New Jersey, for 5 minutes.

Mr. PALLONE. Mr. Chairman, I would like to yield my time to the gentlewoman from Florida.

Ms. CASTOR. Well, I thank the ranking member, Mr. Pallone, very much.

And thank you to our witnesses for being here today.

I want to thank the utility workers all across the country who have flooded into Florida—and I know they did into Texas—to help get the power back on after millions and millions of my neighbors in Florida lost power. So my hats off to them on behalf of the citizens of the State of Florida. They still have some work to do, but they are making good progress.

But I think these extreme weather events, these two hurricanes, in addition to the other events we have seen just in the past few years, require a modern, dramatic response to what is happening with the cost of the changing climate. These disasters are very expensive. And it is time to make a dramatic investment in a modern grid, something that is more resilient, something that serves the need of our citizens in a better way. We have the brightest minds here in America, and we need to put them to work, and we need to put the technology to work, whether that is burying lines that we haven't invested in before, a greater distributed energy grid, building in the renewables over time. I agree they are not the answer in the short term. But in the long term, these distributed grids, building in renewable energy, is going to help us reduce the cost of the changing climate.

We have to do more on-demand management. That has been a battle in the past, and there are some challenges. But we have got to do this. The business models, in many States, simply do not match the challenges ahead of us. And I hear that the Department of Energy wants to be proactive on this. But I don't know how we do that when we have seen such tremendous proposed cuts from the Trump administration in resilience, in research. We have got to rethink that. And I am calling on all of my colleagues who understand the challenges ahead. We can't simply cut our way and think we are going to be able to address these costs and these challenges ahead.

Ms. Hoffman, certainly these cuts, proposed cuts, to research and development and resiliency are going to put us further behind. How do we keep up in an era where we need to be investing more in a modern grid to ensure we don't have the power outages, and we are addressing the costs of the changing climate?

Ms. HOFFMAN. Thank you, very much, for the question.

The administration is focused in its fiscal year 2018 budget on early-stage research. And we really are concentrating on maximizing the effectiveness of work at the Department of Energy. We did provide a budget to Congress for fiscal year 2018, and I know it is under deliberations for the House and Senate. And we look forward to what Congress provides back for what the Department will implement as part of our fiscal year 2018 appropriations.

Ms. CASTOR. You are right. And it is back on the Congress in a lot of ways. And I hope that they are listening and understand the huge cost if we do not address this. Look at what we are facing already in emergency aid packages, flood insurance, rising property insurance, property taxes because local governments have to raise taxes to harden their water/wastewater infrastructure and everything they are doing, just the loss of life that we are seeing.

So my message this morning, on the heels of these disasters, is let's do more working together, everyone in the utility industry, the scientists we have out there, and take this on. This is a real call to action. And I share Mr. Rush's sense of urgency, as he put it.

So, thank you, and I yield back.

Mr. OLSON. The gentlelady yields back.

The Chair now calls upon the gentleman from North Dakota, Mr. Cramer, for 5 minutes.

Mr. CRAMER. Thank you, Mr. Vice Chairman.

And thank you, witnesses, for your service and for being with us today.

I am going to ask of the Chairman first, Chairman Chatterjee, as the policy leaders here, we need to respond to establish a path for base load generation, especially coal. North Dakota is a big coal-producing State. It is mine mouth. It is low cost. It is efficient. And I worry about the early shutdown, the forced shutdown, frankly, of base load generation, especially with plants that have useful life left in them. And it really doesn't do anything, in my view, to protect America's future energy position while also increasing the cost of electricity for consumers.

And, of course, again, speaking to my State, most of these plants belong to vertically integrated utilities, which I think has a special concern about this, where the consumers pay for the facilities whether they are running or they are not running. I think this gets lost a lot of times.

Can you elaborate, from a FERC perspective a little bit, on any strategies that you could deploy that would help adequately compensate base load generation?

Mr. CHATTERJEE. Thank you for the question, Senator—sorry, Freudian slip.

Mr. CRAMER. It happens a lot lately.

Mr. CHATTERJEE. It has a nice ring to it.

Thank you for the question. Obviously, being from Kentucky and having grown up in Kentucky, I have seen firsthand the importance of coal-fired generation and what coal-fired generation means for the delivery of not just affordable but reliable electricity. And, certainly, growing up seeing that, I have an appreciation for the role that coal-fired generation plays in our marketplace.

In terms of what strategies or path forward, the Commission is fuel-neutral. And we will look to ensure that, as our grid undergoes this transformation, that we ensure that we evaluate the attributes of fuel sources to see what values they provide and see if there is a demonstrated need for reliability, whether or not those things can be compensated.

I believe the Democratic nominee for the vacancy on the Commission testified to this last week. And he said that, while currently, per the DOE report, he believed that there were not threats to reliability, even he admitted that we had to closely monitor this and watch this. And I think I would echo those remarks. We are going to closely watch and monitor whether, in fact, transitions in the grid do lead to vulnerabilities and threats to reliability and resilience, and whether, in fact, we would need to take steps to ensure that that need is met.

Mr. CRAMER. Thank you for that.

Along the same lines, as you know, a lot of States, they have taken some steps to try to work around market solutions to preserve these plants and their benefits. But, in most cases, these efforts have been challenged. Understandably, they have been contested on the basis that they undermine your authority or FERC's authority. How can we deal with this? How should we deal with this? Or is this just going to be litigation or regulation by litigation? Is there a way to deal with the States?

Mr. CHATTERJEE. Certainly, it is within the State's purview, and I believe in States' rights. And States, it is their prerogative to determine their sources of generation and their generation mix. When it affects interstate commerce and potentially does have threats to reliability, I think FERC has the authority to weigh in there. I think that it will be something that we will look at closely and carefully, build a record, adhere to the science and engineering and technology of the grid, and make those careful determinations.

Mr. CRAMER. Thank you, and congratulations, by the way.

In my remaining minute, Ms. Hoffman, I want to talk about the role of coal going forward, again, especially with new technologies, the R&D that is being developed for cleaner coal, of fuel emissions, carbon capture, sequestration, utilization, all of those technologies that are very promising but, at this point, not quite to marketability, while at the same time—I guess my question is, how can DOE, both through its R&D and in its advocacy, find ways to build that bridge using the existing tools or maybe expanding on them, especially considering we have tax reform coming up? Do you see any way for DOE and Congress to work to build a bridge to that ultimate future of cleaner coal?

Ms. HOFFMAN. So, Congressman, I would love to continue to work with you in exploring additional ideas. Through our research program, we will continue to invest in advancement in coal technology, utilization of coal, looking at job growth and looking at opportunities to continue to support the coal industry.

Other things that we would like to be able to recognize is the value that coal brings, as the study brought out, and can it be compensated for the services it provides, frequency support, frequency response, fuel diversity.

Mr. CRAMER. Thank you. And good report. I appreciate it.

Thanks all of you.

Thank you, Mr. Chairman.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon the gentleman from California, Mr. McNerney, for 5 minutes.

Mr. MCNERNEY. I thank the chairman.

And I thank the witnesses.

I just want to bring to Mr. Cramer's attention: North Dakota has the biggest wind potential resource of any State in the country. So don't discount alternative energy in North Dakota.

I want to follow up a little bit on Ms. Castor. Yes, we need to build more resiliency into our electric grid. We need to acknowledge climate change because that is one of the drivers. But it is not the only driver: cyber issues, physical threats, other drivers. And as cochair of the bipartisan Grid Innovation Caucus with Mr. Latta, a Republican, our mission is to move forward in that to get the Congress excited about grid innovation and resiliency. So let's keep that line of communication open.

Ms. Hoffman, I want to start out with a question about the disaster. When disasters strike, like the hurricanes that we just saw, there are utilities sharing resources. But what I want to know, are there barriers to the sharing of resources between utilities that we could address here?

Ms. HOFFMAN. Thank you, Congressman, for the question. I think that the biggest barrier is allowing the resources to get to the location of where they need to be as quickly as possible.

Mr. MCNERNEY. Physical barriers?

Ms. HOFFMAN. Physical movement.

Other barriers and other things that we are trying to do is accelerate the assessment time period, which goes down to information sharing as part of the public-private partnership so that we understand exactly what the damage is so we can effectively move resources to respond.

Mr. MCNERNEY. Thank you.

Again, Ms. Hoffman, cyber attacks are becoming greater threats, including State-sponsored attacks, such as the potential connection between Dragonfly and Russia, on attacks on our electric grid. So we must continue to focus on cybersecurity to build our grid cyber resiliency. So, in addition to FERC's Order 829 related to supply chain management, are there additional steps that DOE is or should be taking with regard to supply chain management to the bulk power system?

Ms. HOFFMAN. Congressman, absolutely. It is one of the areas that we all should be focusing on is supply chain management. What the Department is doing is partnering with the supply-chain sector that supports the electric industry, helping them look at vulnerabilities, look at mitigation solutions, but also look at ways to get ahead of the game and really identifying ways to monitor any sort of intrusions that come on the system, but also be able to look for abnormal behaviors.

Mr. MCNERNEY. OK. Good. And we are looking at some legislation that might actually enhance your capabilities in that regard.

Also, there are several traditional reliability and resiliency framework tools, including CAIDI, SAIDI, and SAIFI, if you know what those are, and the interruption cost estimate calculator, is there room for improvement on those tools? Should they be upgraded regularly?

Ms. HOFFMAN. Yes, Congressman. We always should take a look at any tools for new technologies and capabilities to advance the utilization. It will help us, in the long term, define, what does resiliency mean, and what are the cost-effective investments that we should focus on? So all those tools are valuable in establishing a baseline but also helping identify priorities.

Mr. MCNERNEY. In the interest of courtesy, I will yield back. But I am going to submit questions for the record.

Mr. OLSON. I thank my friend.

The Chair now calls upon the gentleman from the Commonwealth of Virginia, Mr. Griffith, for 5 minutes.

Mr. GRIFFITH. Thank you, very much, Mr. Chairman.

In the interest of time, I will submit some questions that I had for the record that I had for some folks. And I will try to abbreviate my questions as much as I can.

Chairman Chatterjee, you have said that the existing coal and nuclear fleet need to be properly compensated to recognize the value they provide the system. Regardless if one agrees or not, it is clear that some States do agree and are taking action within the jurisdiction to compensate generation resources for attributes that are not being properly recognized in the wholesale markets.

Given the current backlog of issues at FERC, how high of a priority do you see FERC placing on the issue of proper compensation in wholesale markets? And as a part of that, let me just say, because of time, I would love to get an extended answer, but for purposes of today's hearing, so that folks at home know, high, medium, or low?

Mr. CHATTERJEE. We can walk and chew gum at the same time. I would say high.

Mr. GRIFFITH. High. OK. I appreciate that very much.

Ms. Hoffman, the recently released DOE staff report found that the uncertainties surrounding New Source Review requirements has led to a significant lack of investment in plant and efficiency upgrades. And I look to the question I just asked where we have acknowledged that coal and nuclear fleets are important for grid reliability across the country. And so we have that lack of investment in plant and efficiency upgrades and that the New Source Review program has impeded or resulted in the cancellation of projects which would maintain and improve reliability, efficiency, and the safety of existing energy capacity—and a lot of times that is coal, but it is other things as well. That is why I have authored two bills to modernize and streamline the New Source Review Program. Can you provide a brief overview, again, looking at another date for a longer answer perhaps, but can you provide what DOE plans that there are to ensure that this burdensome permitting program does not further impact grid reliability? In other words, I am working on the legislative end. What are you doing on the administrative end?

Ms. HOFFMAN. Thank you, Congressman. We are working diligently to streamline the review and permitting process that is in the jurisdiction of the Department of Energy. We are looking, on the transmission side, pre-application process. I would be more than glad to have an in-depth conversation on all the list of activities that we are working on.

[Additional information submitted by Ms. Hoffman follows:]

COMMITTEE:	HOUSE ENERGY AND COMMERCE
HEARING DATE:	SEPTEMBER 14, 2017
WITNESS:	PATRICIA HOFFMAN PAGE: 41, LINE: 17

INSERT FOR THE RECORD

EPA's New Source Review (NSR) Program applies preconstruction review and permitting requirements to certain new and modified sources of air pollution, such as power plants, to meet the air quality goals of the Clean Air Act with respect to criteria pollutants. Decisions regarding improvements or modifications of power plants are the responsibility of the power plant owners, and DOE recognizes that these decisions can have implications for overall grid reliability. Through workshops and public meetings with stakeholders on various energy supply and delivery issues, DOE has heard that industry stakeholders are concerned that continued investments into aging infrastructure might trigger NSR, and some stakeholders view NSR as a barrier to further improvements. Practices and procedures currently exist to manage the reliability of the electricity system. DOE anticipates most if not all power plant operators are engaged with their regional electric reliability entities to anticipate and address reliability issues that may emerge.

The details regarding how the NSR Program is designed and administered are determined by EPA. While power plants may be subject to NSR based on their new or modified status, DOE does not have jurisdiction over how EPA's NSR Program is applied to such power plants. However, in the event that EPA requests technical input from DOE to inform its administration or design of the NSR Program with respect to power plants, DOE is available to work with EPA to provide the requested technical expertise, including providing information on potential heat rate improvements, ongoing R&D to improve these units, or continued analyses of grid reliability and the potential for such efficiency improvements to improve such targets.

Mr. GRIFFITH. And I do appreciate that, anything you provide to our office. I do apologize that, because of hurricanes earlier in the week and now our compressed voting schedule today, that I can't get a lengthier answer.

And, Mr. Chairman, those being the two most vital of my questions—others were important, but those were the two most important—I yield back.

Mr. OLSON. The gentleman yields back.

Seeing no further Members wishing to ask questions, I would like to thank all the witnesses for being here today. And I want to personally apologize for exposing you all to a good old-fashioned Texas goat rope because of the floor votes. I appreciate your patience.

Pursuant to committee rules, I remind Members that they have 10 business days to submit additional questions for the record. I ask that witnesses submit the response within 10 business days upon receipt of those questions.

Without objection, the subcommittee is adjourned.

[Whereupon, at 10:47 a.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

PREPARED STATEMENT OF HON. GREG WALDEN

As you are aware, this hearing was originally scheduled for the beginning of this week but was postponed due to the destruction caused by hurricane Irma. I would like all of those effected by hurricane Irma to know that we are thinking about them and we are doing what we can to hasten the recovery efforts, especially as it pertains to restoring power to the region. Both hurricane Irma and hurricane Harvey have highlighted concerns and challenges that this committee is working to address and which we will be talking about this morning.

As we continue our "Powering America" hearing series today, we will be examining the U.S. electricity system through the important lens of reliability. If there is one thing that we can all agree upon, it is the fact that this country must have an electricity system that provides reliable power to every corner of the country. Everyone in this room understands that electricity is a crucial component in the lives of all Americans and serves as the backbone of the U.S. economy. For these reasons, this committee has always paid special attention to the issue of reliability, which can be seen through our extensive record of hearings and legislation related to the electricity sector.

As noted in previous "Powering America" hearings, the United States electricity system is going through a significant period of transformation which is being driven by several factors ranging from a changing generation fuel mix to the deployment of new energy technologies located at the edge of the grid.

Clearly, the transforming grid is creating exciting new opportunities and benefits for consumers across the country, which is demonstrated by low electricity prices and the deployment of new consumer-focused energy technologies. However, along with the benefits that accompany an evolving grid, there are of course some associated challenges that are causing many stakeholders to rethink how we should go about regulating and operating a 21st century electricity system. Chief among these challenges is improving how we address and ensure grid reliability.

Given the importance and far reaching impact of the grid, multiple entities and stakeholders are working together to make sure that electricity is generated and delivered reliably. Joining us today, we have three entities—the Federal Energy Regulatory Commission, the Department of Energy, and the North American Electric Reliability Corporation—who each play a crucial role in overseeing our electricity system. I look forward to hearing from them. More specifically, I am particularly interested in hearing how these entities are implementing market rules and standards to ensure not only a reliable grid today but to make sure that we have a reliable grid 10 or 20 years from now.

I should also mention that at a later date, we will be hearing from a separate panel of witnesses representing the various types of power producing technologies that generate the Nation's electricity supply. These witnesses will help us understand how various generation resources are working together, under the direction of grid operators, to generate adequate power and to offer essential grid reliability services, such as frequency regulation and voltage support.

As Americans, we have always been incredibly fortunate to have access to reliable electricity at all times of the day and in every region of the country. To maintain this reliable electricity system going forward, we must continue to promote adequate system planning, smart energy policies, and robust technology standards, while still providing electricity-sector participants with the flexibility they need to bring about innovation and sustain low electricity prices. With this goal as a backdrop, I look forward to the remainder of this hearing and would like to thank our witnesses for their patience and flexibility with rescheduling this hearing.

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE

2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115
Majority (202) 225-2927
Minority (202) 225-3641

October 30, 2017

The Honorable Neil Chatterjee
Chairman
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Dear Chairman Chatterjee:

Thank you for appearing before the Subcommittee on Energy on Thursday, September 14, 2017, to testify at the hearing entitled "Part 1: Powering America: Defining Reliability in a Transforming Electricity Industry."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Monday, November 13, 2017. Your responses should be mailed to Allie Bury, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Allie.Bury@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, DC 20426

November 9, 2017

OFFICE OF THE CHAIRMAN

The Honorable Fred Upton, Chairman
Subcommittee on Energy
House of Representatives
Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Upton:

Thank you for your October 30, 2017, letter containing additional questions for the hearing record on "Part I: Powering America: Defining Reliability in a Transforming Electricity Industry."

Enclosed please find my responses to your questions. I want to thank you again for the opportunity to appear before the Subcommittee on Energy on September 14, 2017.

Sincerely,

[redacted]

Neil Chatterjee
Chairman

cc: The Honorable Bobby Rush, Ranking Member
Subcommittee on Energy

Attachment Enclosed

Neil Chatterjee, Chairman
Federal Energy Regulatory Commission
Responses to Question for the Record to
Subcommittee on Energy
House Committee on Energy and Commerce
November 13, 2017

The Honorable Fred Upton

Question 1: As you are aware, New York and Illinois have recently moved forward with a special credit to preserve nuclear power assets and other states are actively considering similar state supports. Those in favor of these "ZEC" credits claim that nuclear power plants provide reliable, zero-emission baseload generation and other benefits.

a. **Do you or FERC have a position on the appropriateness of these credits?**

Answer: Matters related to the New York and Illinois ZEC programs are currently pending before the Commission, and I cannot speak to the merits of those proceedings. However, the Commission held a technical conference in May 2017 to consider the broader issue of interaction between state policy goals and the competitive wholesale markets. I will continue to work with my colleagues on this important issue.

b. **If these nuclear power plants are not needed for reliability, should they be supported by ratepayers if they cannot compete in the market based on cost?**

Answer: Ensuring reliability of the bulk-power system is central to the Commission's mission, and all resources should be fairly compensated for the value they provide to the system. As noted above, proceedings involving the New York and Illinois ZEC programs are currently pending before the Commission.

Question 2. In 2014, FERC began a stakeholder process to reform the process through which market prices are determined and paid. This price formation review period has resulted in significant improvements in the accuracy of price signals, but is not complete. Some of the largest market distortions, such as out of market actions and scarcity pricing, has still not been addressed. The DOE grid study identified further price formation reform as its top recommendation to minimize reliability disruptions, specifically identifying reforms from PJM and MISO. Will you commit to making price formation reform a priority during your tenure, particularly as it pertains to supporting base load generators like nuclear and coal?

a. **Two of the highest impact price formation reforms are expanding price-setting eligibility and implementing scarcity pricing reforms. What are your views on these price formation issues?**

Answer: As I said at the hearing, I will place a high priority on the issue of proper compensation of resources, including nuclear and coal-fired generators, for the value that they provide to the system.

The Commission has taken recent action on both the pricing of fast-start resources and scarcity pricing (or shortage pricing) reforms. On the first of those subjects, the Commission issued a Notice of Proposed Rulemaking for the RTOs/ISOs to address price setting for fast-start resources. The Commission is reviewing comments on the proposed rulemaking, and the subject will continue to be a high priority for me while on the Commission.

On scarcity pricing, the Commission in June 2016 issued a final rule, Order No. 825, which required each RTO/ISO to trigger shortage pricing for any interval in which a shortage of energy or operating reserves is indicated during the pricing of resources for that interval. As with all Commission-approved market reforms, I will monitor the effect of this final rule on the markets, including its effects on resources and load.

Question 3: The DOE Staff Report found that the retirement of base-load coal and nuclear generators has not threatened reliability to date. However, the Report also recommended that FERC explore how to better compensate generators for their resiliency benefits if FERC concludes reliability is threatened.

a. **Can you describe what steps FERC has taken to address the issue of compensating generators for reliability and resiliency attributes?**

Answer: I understand the importance of ensuring a reliable and resilient bulk electric system for our nation, and I recognize the contributions that coal-fired and nuclear baseload generation traditionally have made toward those goals. The Commission has undertaken several steps to support fair compensation for reliability services. For instance, in 2011 FERC issued Order No. 755, which addressed compensation for frequency regulation in wholesale markets operated by RTOs and ISOs. Order No. 755 required RTOs and ISOs to compensate frequency regulation in a manner that allowed market operators to take advantage of the capabilities of faster-ramping resources to improve operational and economic efficiency of the transmission system and reduce costs to consumers in organized wholesale markets. In June 2016, FERC issued Order No. 825, which aligns the time frames by which resources are compensated and by which resources respond to operating instructions and required RTOs and ISOs to trigger shortage pricing for any dispatch interval during which a shortage of energy or operating reserves occurs. Both of these reforms help maintain reliability by facilitating accurate market signals of system conditions, which encourages resources to follow commitment and dispatch instructions.

b. How should resiliency be valued?

Answer: This issue is raised in the September 28, 2017, Notice of Proposed Rulemaking proposed by the Secretary of Energy (DOE NOPR). The Commission has invited all interested persons to submit comments regarding the DOE NOPR, including comments on how to define resilience and whether RTO/ISO markets properly value resilience. Those comments should inform me and my colleagues on the issues regarding how to value resiliency. I am working with my colleagues to take action in response to the DOE NOPR.

Question 4: The DOE Staff Report found that FERC should expedite its efforts regarding its price formation efforts. However, FERC has already been working on price formation issues in various dockets since 2014.

a. Can you provide a preview of where these various efforts are heading?

Answer: Although I cannot provide a preview of what the final result of the Commission's price formation efforts will be, I note that I put a high priority on the Commission's ongoing price formation efforts. As part of these efforts, the Commission has issued two final rules: one regarding settlement intervals and shortage pricing (Order No. 825) and one regarding offer caps (Order No. 831). The Commission is reviewing comments in two pending price formation proceedings: the fast-start pricing NOPR (Docket No. RM17-3) and the uplift allocation and transparency NOPR (Docket No. RM17-2).

Question 5: As a regulator, you are undoubtedly concerned with the reliability of the electric grid. At the PURPA hearing on September 6, 201 7, we heard that utilities need the flexibility to curtail QF output for reliability reasons. Do have thoughts on the circumstances under which a utility should be able curtail QF energy to maintain system reliability?

Answer: The Commission's PURPA regulations recognize the importance of system reliability. The regulations permit a purchasing utility to curtail a QF's output on a non-discriminatory basis in system emergencies when the continuation of QF purchases would contribute to such an emergency. The regulations define a system emergency as a condition on a utility's system which is likely to result in imminent significant disruption of service to customers or is imminently likely to endanger life or property.

Question 6: Under PURPA, FERC can exercise its enforcement authority to require a state regulatory authority to implement the Commission's regulations. However, during disputes between QFs, utilities, and state commissions, FERC rarely

exercises its enforcement authority. Instead, FERC usually issues a "*Notice of Intent Not to Act*" which then allows the underlying petitioner to bring its own action before a U.S. District Court.

a. **Do you know why FERC is reluctant to use its enforcement authority in such cases?**

b. **Should any changes be made to PURPA with respect to FERC's enforcement authority?**

Answer: In 1983, the Commission issued a policy statement explaining its enforcement role under section 210 of PURPA. *See Policy Statement Regarding the Commission's Enforcement Role Under Section 210 of the Public Utility Regulatory Policies Act of 1978*, 23 FERC ¶ 61,304 (1983). There the Commission stated that it is not required by PURPA to undertake enforcement action and that it necessarily viewed its enforcement role, given the statutory structure, as limited. Moreover, to ensure the most efficient allocation of Commission resources, rather than participate in the QF litigation cases around the country, the Commission allows the parties to these cases, who often are QF developers or investor-owned utilities, to pursue their litigation at their own expense. Even then, however, the Commission may issue a declaratory order to express its views on PURPA and the relevant Commission regulations and precedent, which aids the court in resolving the parties' litigation. As to changes in PURPA, as I mentioned at the hearing, I believe that any significant changes to PURPA require Congressional action. Nevertheless, I am committed to working with my colleagues to evaluate whether there are areas where the Commission's implementation of PURPA can be improved.

The Honorable Robert Latta

Question 1: The DOE Staff Report found that the retirement of base-load coal and nuclear generators has not threatened reliability to date. However, the Report also recommended that FERC explore how to better compensate generators for their resiliency benefits if FERC concludes reliability is threatened.

a. **Can you describe what steps FERC has taken to address the issue of compensating generators for reliability and resiliency attributes?**

Answer: I understand the importance of ensuring a reliable and resilient bulk electric system for our nation, and I recognize the contributions that coal-fired and nuclear baseload generation traditionally have made toward those goals. The Commission has undertaken several steps to support fair compensation for reliability services. For instance, in 2011 FERC issued Order No. 755, which addressed compensation for frequency regulation in wholesale markets operated by RTOs and ISOs. Order No. 755 required RTOs and ISOs to compensate frequency regulation in a manner that allowed market operators to take advantage of the capabilities of faster-ramping resources to improve operational and economic efficiency of the transmission system and reduce costs to consumers in organized wholesale markets. In June 2016, FERC issued Order No. 825, which aligns the time frames by which resources are compensated and by which resources respond to operating instructions and required RTOs and ISOs to trigger shortage pricing for any dispatch interval during which a shortage of energy or operating reserves occurs. Both of these reforms help maintain reliability by facilitating accurate market signals of system conditions, which encourages resources to follow commitment and dispatch instructions.

Question 2: How should resiliency be valued?

Answer: This issue is raised in the September 28, 2017 Notice of Proposed Rulemaking proposed by the Secretary of Energy (DOE NOPR). The Commission has invited all interested persons to submit comments regarding the DOE NOPR, including comments on how to define resilience and whether RTO/ISO markets properly value resilience. Those comments will help inform me and my colleagues on how to value resiliency. I am working with my colleagues to take action in response to the DOE NOPR.

Question 3: Can you talk more about the Critical Infrastructure Protection Standards that FERC and NERC have worked together on? Specifically, could you talk about the tiered approach to cybersecurity that utilities began to implement in 2016?

Answer: On November 22, 2013, the Commission approved Order No. 791, which became effective on July 1, 2016, and implemented a tiered approach to the cyber security controls used to protect the reliable operation of the Bulk-Power System. These tiers (high-impact, medium-impact, and low-impact) specify the level of cyber protection appropriate for systems based upon their importance to the reliable operation of the Bulk-Power System. In general, the systems that qualify as high-impact (e.g., large control centers) and medium-impact (e.g., smaller control centers, plus certain generation and transmission assets) were equivalent to the systems covered under the "non-tiered approach," used prior to July 1, 2016. The inclusion of low-impact systems (e.g., certain substations) now ensures that all cyber systems associated with the reliable operation of the Bulk-Power System receive some level of protection based on their importance to reliable operation.

The Honorable Gregg Harper

Question 1: **Are regulated markets seeing the same baseload generation closures as seen in competitive markets? If not, what is protecting baseload generation in regulated markets?**

Answer: There has been a national trend of retirements of coal-fired and nuclear generators. There are a number of reasons for the retirements, and the reasons may vary among regions of the country.

The Honorable Adam Kinzinger

Question 1: **In this Committee, we recently heard testimony from the RTOs on issues including reliability, resiliency, and the successful operation of wholesale markets. PJM, the RTO that operates in my Congressional District, offered testimony regarding energy price formation reforms and the importance of valuing base load generation. The Department of Energy released a report on grid reliability recently that echoed the importance of energy price formation reform at the FERC.**

a. **Can you share what FERC plans to do to implement these reforms and when we can expect these reforms to be in place?**

Answer: While I cannot discuss specific timelines for Commission action, I note that I place a high priority on the Commission's ongoing price formation efforts. As part of those efforts, the Commission issued two final rules that are currently being put into place by RTOs/ISOs: one regarding settlement intervals and shortage pricing (Order No. 825) and one regarding offer caps (Order No. 831).

In addition, the Commission is reviewing comments in two pending price formation proceedings: the fast-start pricing NOPR (Docket No. RM17-3) and the uplift allocation and transparency NOPR (Docket No. RM17-2).

Question 2: **At the recent hearing on PURPA, we heard testimony that QF developers site their project for the benefit of investors, choosing the quickest and cheapest site regardless of the impact to the grid or to reliability.**

a. **Can FERC take regulatory action to address this concern?**

Answer: The fundamental elements of PURPA, such as the requirement that electric utilities offer to purchase electric energy from qualifying facilities, are established by statute. Accordingly, as I mentioned at the hearing, changing these fundamental elements of PURPA would require congressional action. Nevertheless, I am committed to working with my colleagues to evaluate whether there are areas where the Commission's implementation of PURPA can be improved.

The Honorable Morgan Griffith

Question 1: Last year, FERC issued proposed rules concerning the participation of electric storage resources and distributed energy resources (DER) in wholesale electric markets. Do you have a timeline on moving forward on this? Do you support including in any final rule a role for state and local regulatory authorities to permit an aggregation of distributed energy resources on local distribution grids, similar to the role they have to permit the aggregation of demand response resources?

Answer: While I cannot discuss specific timelines for Commission action, removing barriers to ensure access to the market by all resources is important to me and I expect to act on this matter in a timely fashion. The Commission is currently reviewing the comments filed in response to the proposed rule, including comments regarding the role state and local regulatory authorities play with respect to the local distribution grid.

The Honorable Bill Flores

Question 1: FERC has long held that it "does not pick winners or losers" regarding the fuels for generating electricity—rather its role is to promote competition through market mechanisms.

a. How does this philosophy square with the fact that some generators have characteristics or attributes, such as onsite fuel, that allow them to provide additional value in terms of reliability or resiliency?

Answer: While FERC prefers to rely on competitive forces in appropriate circumstances, it recognizes that other regulatory measures are sometimes necessary in wholesale electricity markets to ensure just and reasonable rates. The appropriate valuation of resilience is an issue in the September 28, 2017 Notice of Proposed Rulemaking proposed by the Secretary of Energy (DOE NOPR). The Commission is reviewing the record in that proceeding, including extensive comments and reply comments. I am working with my colleagues to take action in response to the DOE NOPR.

Question 2: **At last week's hearing on PURPA reform, we heard about situations where a host utility has no need for additional power, but are nevertheless required to purchase the QF output under section 210 of PURPA (i.e, the mandatory purchase obligation).**

a. **How do you respond to concerns by utilities that this requirement is causing reliability concerns?**

b. **Should state commissions be able to suspend the mandatory purchase requirement in situations where it determines that the utility does not need the QF output in order to meet its obligation to serve load?**

Answer: The Commission's PURPA regulations permit a purchasing utility to curtail a QF's output on a non-discriminatory basis in system emergencies when the continuation of such purchases would contribute to the emergency. The regulations define a system emergency as a condition on a utility's system which is likely to result in imminent significant disruption of service to customers or is imminently likely to endanger life or property.

Section 210(a) of PURPA imposes an obligation on electric utilities to purchase a QF's output. That section provides that the Commission prescribe rules requiring electric utilities to offer to purchase electric energy from QFs. As I mentioned at the hearing, I believe that any significant changes to PURPA require Congressional action; however, I am also committed to working with my colleagues to evaluate whether there are areas where the Commission's implementation of PURPA can be improved.

The Honorable Richard Hudson

Question 1: **The DOE recently released an assessment of the electricity grid's reliability and resiliency in the wake of recent baseload power plant closures. While the study confirmed adequate reserve margins and mechanisms to maintain reliability, it identified significant remaining work in the area of grid resiliency. The report recommends that FERC properly value essential reliability services for the grid and create new markets and regulatory mechanisms to compensate market participants for these essential services. As you may know, before losing quorum FERC was in the middle of a "price formation review." Is finalizing that review a priority for you?**

a. **Do you agree with the Department of Energy that reforms should include measures that adequately value the reliability and resiliency benefits of technologies like nuclear power?**

Answer: It is important to ensure that resources providing essential reliability services to the grid are fairly compensated for the value that they provide. As noted in my testimony, FERC has been evaluating the essential reliability services necessary for the reliability of the grid. The Commission also has been actively working to explore issues related to price formation in wholesale markets, and I am committed to continuing to work with my colleagues on these important issues. The issue of the appropriate valuation of resilience is raised in the September 28, 2017, Notice of Proposed Rulemaking proposed by the Secretary of Energy (DOE NOPR). I am working with my colleagues to take action in response to the DOE NOPR.

Question 2: In 2014, FERC began a stakeholder process to reform the process through which market prices are determined and paid. This price formation review period has resulted in significant improvements in the accuracy of price signals, but is not complete. Some of the largest market distortions, such as out of market actions and scarcity pricing, has still not been addressed. The DOE grid study identified further price formation reform as its top recommendation to minimize reliability disruptions, specifically identifying reforms from PJM and MISO. Will you commit to making price formation reform a priority during your tenure, particularly as it pertains to supporting base load generators like nuclear and coal?

a. **Two of the highest impact price formation reforms are expanding price-setting eligibility and implementing scarcity pricing reforms. What are your views on these price formation issues?**

Answer: As I said at the hearing, I will place a high priority on the issue of proper compensation of resources, including coal-fired and nuclear generators, for the value that they provide to the system.

As part of its price formation efforts, the Commission has addressed both pricing of fast-start resources and scarcity pricing (or shortage pricing) reforms. On the first of these subjects, the Commission issued a Notice of Proposed Rulemaking for the RTOs/ISOs to address price setting for fast-start resources. The Commission is reviewing comments on the proposed rulemaking. This effort is ongoing and will continue to be a high priority in my work on the Commission.

On scarcity pricing, the Commission issued a final rule in June 2016, Order No. 825. The final rule required each RTO/ISO to trigger shortage pricing for any interval in which a shortage of energy or operating reserves is indicated during the pricing of resources for that interval. As with all Commission-approved market reforms, the Commission and its staff will monitor the effect of this final rule on the markets, including its effects on resources and load.

Question 3: **As intermittent energy sources, such as wind and solar, increase market share and clear as the marginal generator in an increasing number of hours during the day, wholesale power prices have plummeted. This wholesale power drop could eventually force around-the-clock baseload capacity, like nuclear power, out of the market. The DOE grid study recommended that negative price offers be mitigated where possible. What should FERC do in the short- term to further examine some of these market design issues?**

a. **Will you work with RTOs like PJM to swiftly implement market changes to reduce negative price offers?**

Answer: The Commission is actively addressing price formation. While this effort to-date has not specifically addressed negative offer prices, the goal of price formation is for market prices to better reflect actual production costs at all times and under all system conditions. I cannot prejudge either the timing or content of any market rule changes relating to negative price offers. Nonetheless, the issue of wholesale power price formation during off-peak periods warrants careful examination, and the impact on the incentives these prices send should be understood prior to the Commission taking action.

Question 4: **Over the past year, the Commission has accelerated its efforts to facilitate integration of electric storage projects into wholesale electricity markets. A variety of new storage technologies have emerged, and the Department of Energy and the national labs have programs in place, albeit small, to tackle key performance and cost challenges that inhibit these technologies widespread deployment. What role do you see energy storage playing in the future of the organized wholesale electricity markets and transmission system?**

a. **What regulatory barriers are in place that inhibit new storage technologies ability to participate in organized wholesale electricity markets?**

Answer: I believe that the nation should seek to rely on all forms of energy resources, including storage resources. The Commission recently proposed new requirements to reduce barriers for electric storage participation in organized wholesale electric markets. Those barriers may include issues such as the bidding requirements the ISOs/RTOs impose on resources that want to participate in the wholesale markets. The Commission is reviewing comments on the proposed rulemaking. This effort is ongoing and will continue to be a high priority in my work on the Commission.

b. **As FERC looks at properly valuing baseload electricity generation like coal and nuclear, what challenges must the Commission tackle when it comes to storage's benefits to the grid? How should it be compensated for its benefits to grid resiliency and reliability?**

Answer: In January 2017, the Commission issued a Policy Statement with respect to electric storage resources that seek to concurrently recover costs through cost-based and market-based rates. In that Policy Statement, the Commission provided flexibility regarding compensating these resources, so long as they meet certain requirements. This guidance is intended to help ensure that these resources can operate at maximum efficiency to benefit the electric system and consumers.

The Honorable Jerry McNerney

Question 1: **There's been discussion about the connection between markets and reliability and resiliency. Yet not all states regulators distinguish between reliability and resiliency.**

a. **Do you believe states should make a distinction between the two?**

Answer: Reliability and resilience are two related but different concepts. As discussed in my response to part (c) below, there could be advantages to establishing greater clarity as to the distinction between reliability and resilience.

b. **Does the electric sector use a standard definition of resiliency in both the distribution system and the bulk power system?**

Answer: I am not aware of commonly used metrics for measuring grid resilience.

c. **Are there potential benefits of having a more industry-wide accepted term or definition for resiliency?**

Answer: An industry-wide accepted definition of resilience potentially could facilitate: a) quantification and development of metrics to measure resilience; b) development of technology-neutral services to provide resilience; c) determination and justification of the required level of resilience in a region or RTO/ISO; and d) development of a mechanism to procure the services to deliver the required level of resilience in a transparent manner.

Question 2: **What barriers exist for utilities and for the federal government as it relates to utilities sharing resources during emergencies, such as hurricane response?**

Answer: Utilities routinely offer mutual assistance to speed recovery from major events such as hurricanes and typically have agreements in place to facilitate that assistance. This assistance may be limited by crew availability, e.g., entities providing mutual assistance retain enough crews to maintain their own continuity of operations.

Question 3: Your testimony mentioned that FERC assured companies won't be penalized for helping restore service. What are the potential penalties utilities face in these circumstances and which are FERC waiving?

Answer: Owners of transmission facilities operated at 200 kV and above are required by NERC Reliability Standard FAC-003-4 to maintain minimum clearance distances between transmission lines and vegetation on and along transmission rights-of-way in accordance with the intervals and specifications of the entity's vegetation management work plan. Failure to complete the required tasks without documented modifications could result in penalties of up to $1.2 million per day per violation.

In a statement I issued jointly with NERC President and CEO Gerry Cauley on September 12, 2017, we indicated that we would consider the actions of entities assisting others from the impacts of Hurricane Irma to be positive and to not negatively impact compliance considerations with respect to Reliability Standard FAC-003-4.

Question 4: CIP standards are frequently updated given a rapidly evolving electric grid. Has FERC received comments from industry stakeholders regarding difficulties implementing CIP standards while new versions of CIP standards are being developed simultaneously?

Answer: Industry stakeholders have commented on the difficulties of implementing these sometimes overlapping revisions. In response to these comments, the Commission has extended the effective date of an approved, yet not effective, CIP Reliability Standard, which has the effect of minimizing the burden from potentially overlapping revisions. The Commission is sensitive to the implementation difficulties industry may encounter in implementing revised CIP Reliability Standards and will continue to work with industry stakeholders to identify and address these difficulties while maintaining the security of the bulk-power system.

Question 5: How does additional behind-the-meter activity at the distribution level potentially affect the bulk power system? Is behind-the-meter information and data being shared between utilities, state regulators, and federal entities – including FERC, NERC, and DOE? Are there areas for improvement?

Answer: Additional behind-the-meter activity can alter how the distribution system interacts with the Bulk-Power System. Industry has identified several potential Bulk-Power System reliability issues resulting from increased distributed energy resources

(DERs), including increased ramping requirements and challenges with forecasting load. These are important issues that Commission has begun to explore in the context of the ongoing rulemaking proceeding addressing the integration of electric storage resources and aggregations of distributed energy resources.

NERC recently published a Reliability Guideline that outlined the minimum data needs for bulk power system planners and operators. The NERC DER Task Force recommends that, even in regions with currently low penetrations of DERs, minimum data collection requirements for interconnected DERs be established to help adequately assess future DER deployments. DOE, EIA, and FERC collect some general information on behind-the-meter aggregated capacity, but this data is not sufficiently specific or detailed to address the Bulk-Power System minimum data needs outlined by NERC.

The Honorable Peter Welch

Question 1: In DOE's recent request that FERC raise the price of so called "baseload power" to keep coal and nuclear plants online, the agency says it's necessary because of "energy outages expected to result from the loss of this fuel-secure generation" and because of "recognition that organized markets do not pay generators for all the attributes they provide."

a. **Whether or not that is true, do you believe generators of solar, wind, and energy storage are compensated fully for their attributes in wholesale markets?**
b. **Do wholesale markets price any electricity source based on their attributes and how they benefit the public?**

Answer: As noted in my testimony, FERC generally has remained resource- and fuel-neutral in fulfilling its core obligations to ensure the reliability of the bulk-power system and to maintain just and reasonable wholesale electric rates. The Commission seeks to ensure that all generators, including solar, wind and energy storage, are fairly compensated for the value they provide to the bulk power system. For instance, in 2011, FERC issued Order No. 755, which allowed market operators to take advantage of the capabilities of faster-ramping resources, including energy storage resources, to improve operational and economic efficiency of the transmission system and reduce costs to consumers in organized wholesale markets. More recently, on November 17, 2016, the Commission issued a Notice of Proposed Rulemaking on electric storage participation in RTO and ISO markets. The NOPR proposed in part to require each RTO and ISO to reduce barriers to participation of electric storage resources in the organized wholesale capacity, energy and ancillary service markets.

c. Do you think DOE is suggesting that FERC create a Value of Coal Tariff to price in non-monetizable attributes?

Answer: DOE has asked the Commission to evaluate whether there are steps the Commission may take to address the value that certain resources may bring to the organized markets that may not be recognized today.

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
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October 30, 2017

Ms. Patricia Hoffman
Acting Under Secretary for Science
Acting Assistant Secretary for the Office of Electricity
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Ms. Hoffman:

Thank you for appearing before the Subcommittee on Energy on Thursday, September 14, 2017, to testify at the hearing entitled "Part 1: Powering America: Defining Reliability in a Transforming Electricity Industry."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Monday, November 13, 2017. Your responses should be mailed to Allie Bury, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Allie.Bury@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

Department of Energy
Washington, DC 20585

November 22, 2017

The Honorable Fred Upton
Chairman
Subcommittee on Energy
Committee on Energy and Commerce
U. S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On September 14, 2017, Patricia Hoffman, Acting Assistant Secretary, Office of Electricity Delivery and Energy Reliability, testified regarding "Defining Reliability in a Transforming Electricity Industry".

Enclosed are answers to questions submitted by Representatives Griffith, Hudson, McNerney and you to complete the hearing record.

If you need any additional information or further assistance, please contact me or Fahiye Yusuf, Office of Congressional and Intergovernmental Affairs at (202) 586-5450.

Sincerely,

[redacted]

Marty Dannenfelser
Deputy Assistant Secretary for House Affairs
Congressional and Intergovernmental Affairs

Enclosures

cc: The Honorable Bobby Rush
Ranking Member

QUESTION FROM CHAIRMAN UPTON

Q1. One of the DOE's most important roles is overseeing the national labs.

Q1a. What are the national labs doing to improve grid reliability and resiliency?

A1a. The laboratory system is providing foundational support to the DOE Grid Modernization Initiative, a cross-DOE initiative to frame and deliver a coordinated DOE grid modernization strategy for the Nation. Grid reliability and resilience are key objectives for this effort, along with outcomes of affordability and flexibility. In 2015, twelve of the Nation's national laboratories formed the Grid Modernization Laboratory Consortium (GMLC) to collectively support the DOE initiative and are delivering a portfolio of research that is delivering:

- advanced system operational and control tools to deliver real-time, predictive tools and controls to improve resilience by reducing system outages,
- next generation sensing and measurement concepts that provide improved situational awareness of system risk,
- device testing and integration tools to accelerate industry adoption of fundamental grid concepts,
- planning and design tools that leverage fundamental math and high performance computing to improve the speed and accuracy of grid designs that are more resilient,
- security and resilience tools that better detect and protect against "all hazards" including cyber, physical, extreme weather and traditional system equipment failure risks, and
- institutional support to provide tools and data sets that states and regions can use to better improve resilience and reliability locally.

Over 100 partners from industry and the states are involved in this effort. DOE awarded $30 million in August, 2017, for seven new resilient distribution projects to develop and validate innovative approaches to enhance the resilience of distribution systems—including microgrids—with high penetration of clean distributed energy resources (DER) and emerging grid technologies in different regions across the United States.

Beyond the GMLC efforts, a number of the national laboratories have substantial capabilities and research programs delivering fundamental advances that promise to improve industry practice and tools. These capabilities include modeling and simulation centers of excellence such as the Electricity Infrastructure Operations Center at the Pacific Northwest National Laboratory, which provides advanced grid operations and control data and tool sets to help industry and academia advance their grid innovations. Sandia National Laboratory operates a Battery Testing Laboratory to ensure safety performance of emerging grid energy storage concepts. Idaho National Laboratory has a full distribution system upon which tests are performed to validate the resilience of new SCADA (supervisory control and data acquisition) and industrial controls. The National Renewable Energy Laboratory has a new test facility to evaluate the performance of new renewable energy concepts in hardware-in-the-loop testing. These and other Laboratory assets across the 12 GMLC members collectively provide important capabilities to enhance the reliability and resilience of the Nation's electric power infrastructure.

QUESTION FROM REPRESENTATIVE GRIFFITH

Q1. In the question and answer period of the September 14th hearing on grid reliability, you stated that the Department of Energy (DOE) was working diligently to streamline the New Source Review (NSR) permitting process that is within the jurisdiction of the DOE. Can you expand on that and share the details of the work DOE is working on?

A1. Through workshops and public meetings with stakeholders on various energy supply and delivery issues, DOE has heard that industry stakeholders are concerned that continued investments into aging infrastructure might trigger NSR, and views NSR as a barrier to further improvements. Practices and procedures currently exist to manage the reliability of the electricity system. DOE anticipates most if not all power plant operators are engaged with their regional electric reliability organizations to anticipate and address reliability issues that may emerge.

The details regarding NSR program design and administration are determined by the Environmental Protection Agency (EPA). While power plants may be subject to NSR based on their new or modified status, DOE does not have jurisdiction over how EPA's NSR program is applied to such power plants. However, in the event that EPA requests technical input from DOE to inform its administration or design of the NSR program with respect to power plants, DOE is available to work with EPA to provide the requested technical expertise, including providing information on potential heat rate improvements, ongoing R&D to improve these units, or continued analyses of grid reliability and the potential for such efficiency improvements to improve such targets.

QUESTION FROM REPRESENTATIVE HUDSON

Q1. The Department's August 2017 "Staff Report on Electricity Markets and Reliability" acknowledges, cost-competitive energy storage "will be critical" to balance the grid under high levels of variable renewable energy. As electricity systems move towards greater variable renewables, bulk energy storage will become increasingly important – capturing excess electricity, including renewable energy generation, when demand and prices are low, and then utilizing that energy during peak demand times with low storage cost. New low- cost systems are currently being pioneered at the national labs, but are not yet commercially viable. Despite energy storage's large potential, the Obama Administration failed to commit the resources and expertise necessary to tackle key performance and cost barriers to the increased utilization of the technology. Historically, the Department's research programs have had the greatest impact when resources are focused on very clear, specific goals. Given the Department's focus on "doing more with less," would setting this type of technology goal ensure scant federal dollars are being efficiently utilized to meet goals important for U.S. innovation leadership? A goal, similar to the SunShot Initiative, which set out a goal in 2011 for more affordable solar power and has met nearly 90% of their original cost target in just six years ($0.23 to $0.06 per kilowatt-hour for utility-scale photovoltaic (PV) solar power).

A1. Specific technology goals are tremendously valuable in ensuring a focused research and development agenda, and the energy storage goals are critical to maintaining U.S. leadership in the technology. The Office of Electricity Delivery and Energy Reliability's (OE's) Energy Storage program has set clearly defined goals for specific, grid-scale energy storage technologies.

The economic viability of energy storage technology is dependent upon the price of electricity, which varies widely in the United States, as well as the application of the technology, which is also influenced by local conditions. The goals pertinent to grid-scale energy storage are related to the magnitude and duration of energy output, costs, and cycles (or effective life), and are being pursued by the program.

In addition, OE is exploring the use of alternatives to certain fundamental materials now used in energy storage systems, especially rare elements such as lithium, vanadium, and cobalt. Currently, the potential for cost reduction is limited by the cost and availability of fundamental materials. Finding alternatives to using these rare elements would lead to significant cost reductions and address potential supply chain issues. The sources of these rare elements are typically located in other regions of the world, including China. Other industries' uses for these rare elements can also restrict their availability. A predictable and cost-effective supply of fundamental materials for energy storage systems will help realize the potential of the technology and enable a robust U.S. manufacturing capability and contribute to U.S. energy dominance.

Q1a. Would a StorageShot fit with the Department's recent announcement on refocusing SunShot resources on resilience, reliability, and storage?

A1a. Energy storage can provide multiple benefits for the electric grid, including helping with increased penetration of solar and wind. However, energy storage has a much greater value that goes beyond the single purpose of assisting deployment of renewables.

OE is focused on applying the technology's ability to consume, store and deliver energy for a variety of purposes. To do so effectively will require that it functions within complex grid systems in various ways. Examples include providing important grid services, such as frequency regulation, peak shaving, flexible operation to address variability from multiple sources, and emergency back-up power. OE has capabilities in grid engineering to help integrate new technologies and is pursuing multiple applications of energy storage technology.

Q1b. It is my understanding that current research on energy storage technology is more focused on transportation-uses. How can we bolster efforts to improve innovative grid-scale energy storage technologies?

A1b. The Office of Energy Efficiency and Renewable Energy (EERE) addresses energy storage for transportation purposes, while OE is focused on energy storage technologies for grid-scale applications aside from pumped-storage hydropower, which is by the EERE hydropower program. The Federal research investments in vehicle technologies are greatly advancing the broader energy storage field, but there are unique challenges for grid-scale energy storage that these investments do not address. The 2013 DOE Grid Energy Storage report identified four primary challenges limiting wider-scale deployment of new grid energy storage technologies: the development of cost-competitive technologies, improved safety and reliability, standardized valuation methods, and industrial acceptance of the technology. This Report provides underlying principles for the DOE OE Energy Storage program's research and development efforts.

To improve the deployment of new grid-scale energy storage technologies, the lifetimes of these systems may need to advance well beyond the targets set for electric vehicles. Today, electric vehicle batteries are expected to survive 1,000–1,500 deep charge and discharge cycles before replacement. For wider scale adoption of grid scale energy storage, these technologies may need to survive 8,000–10,000 cycles, and do so at a comparable price point to vehicle batteries. Focused research and development investments aimed at the four key challenges outlined in the 2013 Grid Storage Report will help address the unique performance and cost requirements necessary for grid scale energy storage applications.

Pumped storage hydropower is able to provide storage at large scale and duration, but faces its own suite of challenges related to the design, operation, and valuation of facilities as they provide reliability and resiliency to a less predictable power system. EERE's investments are designed to drive innovation in pumped storage design and operations that maximize its response time and flexibility and minimize any environmental impacts.

QUESTIONS FROM REPRESENTATIVE MCNERNEY

Q1. There's been discussion about the connection between markets and reliability and resiliency. Yet not all states regulators distinguish between reliability and resiliency.

Q1a. Do you believe states should make a distinction between the two?

A1a. Grid reliability and grid resilience are related but separate concepts. To minimize confusion, the electricity community should agree on standard definitions for both. Standard definitions for reliability have been in use and applied for many years. Standard definitions for resilience would be helpful, but it is also important to note that investments in grid infrastructure and improved function should be determined according to the objectives set forth by local, State, regional, or Federal government authorities and that strategies to improve resilience (and their associated costs) will be very dependent upon local situations.

Q1b. Does the electric sector use a standard definition of resiliency in both the distribution system and bulk power system?

A1b. Not yet, but various study groups are working on the problem. For example, one of the projects sponsored by DOE's Grid Modernization Lab Consortium is working with stakeholder groups to develop proposed new or updated definitions and metrics for several key grid concepts, including reliability and resiliency.
One reason standardizing a definition is challenging is potential threats to utilities vary widely from region to region. A well-designed, cost-effective program to enhance resilience at one utility may be inappropriate for another.

Q1c. Are there potential benefits to having a more industry-wide accepted term or definition for resiliency?

A1c. Yes. Common terms and metrics are an aid to clearer discussions and better programs to enhance utility systems' resistance to stressful events or conditions, and to accelerate system recovery from such events. Resilience objectives and associated strategies, however, are likely to be shaped by local and state authorities so as to address their specific needs.

Q2. DOE has entered into a cooperative cyber security capabilities program with members of APPA and NRECA.

Q2a. How do you see this valuing reliability and resiliency, and are there opportunities to expand this program?

A2a. These projects are working to increase reliability and resiliency at electric cooperative and public power utilities. Both the American Public Power Association (APPA) and the National Rural Electric Cooperative Association (NRECA) have direct links to public power providers and electric cooperatives, allowing them to reach a broad membership base. This DOE-funded cybersecurity work builds on previous efforts to continue improving the security culture within municipal utilities and electric cooperatives. Both projects are focusing on efforts to further enhance a culture of security and resiliency among their members by advancing the development of cybersecurity tools and guidelines; evaluating and mitigating cyber and physical system vulnerabilities; researching, developing, and adopting emerging technologies to improve resilience and security; and enhancing capabilities to share key information among public power providers.

DOE helps address the continuing cybersecurity needs of energy owners and operators, and has defined goals, objectives, and activities to reduce the risk of energy disruptions due to cyber incidents. DOE's works with its partners to address growing threats and promote continuous improvement to strengthen today's energy delivery systems, as well as develop game-changing solutions that will create secure, resilient, and self-healing energy systems for tomorrow.

Q3. Does DOE collect information on power outage or power disruption causes?

A3. DOE collects information about U.S. electric power system outages, disruptions, and potential disruptions that meet specified criteria through Form OE-417, the Electric Emergency Incident and Disturbance Report. Form OE-417 establishes requirements for utilities, balancing authorities, and reliability coordinators to file a report, including information about the cause of a disruption. The reported information enables DOE to maintain awareness of electric emergency incidents and disturbances so that the U.S.

Government can quickly respond to energy emergencies that may impact the Nation's infrastructure. The reports also provide data for post-event analysis. DOE also utilizes the Environment for Analysis of Geo-Located Energy Information (EAGLE-I), which was developed by DOE and the Oak Ridge National Laboratory, to provide situational awareness through near real-time monitoring of electricity outages and geospatial mapping of energy infrastructure. This information is utilized by DOE, other Federal agencies, and select state entities to assess the current status of the energy system and to inform responders and decision makers during an incident.

Q4. Cyber mutual assistance is relatively new, but they have great potential to enhance electricity system coordination. Is there any role for DOE to enhance CMAs?

A4. Based on lessons learned from major cyber incidents overseas and recent exercises, the industry-led Electricity Subsector Coordinating Council (ESCC) recommended the formation of a Cyber Mutual Assistance (CMA) program. The program is an extension of the electric power industry's longstanding approach to sharing personnel and equipment when responding to natural disasters. DOE has had preliminary discussions with industry to determine the best way to engage in the effort and integrate expertise and resources. Industry has been very receptive to DOE supporting industry efforts.

Q5. During the Energy Subcommittee hearing on September 14, you mentioned that there are barriers for utilities to share resources during emergencies, such as hurricane response efforts. Can you elaborate on what barriers exist for utilities and for the federal government on these efforts?

A5. One of the biggest challenges for sharing resources is the ability to get those resources to the affected areas, particularly where there is significant debris and other operational priorities for law enforcement and emergency response personnel. This is further complicated during an island response because they necessitate equipment and crews being transported by air and sea. Getting an accurate damage assessment to validate what resources are needed to expeditiously restore power is another challenge. To that end, DOE is working with its national laboratories to quickly develop flood inundation maps after an event and provide aerial imagery to electricity industry responders.

Q6. To what extent has the increased utilization of distributed energy resources, IoT devices, and other smart grid resources affected the potential sharing of customer data that that is potential threat and vulnerability information as it relates to utility-EISAC information sharing?

A6. This involves three general information types: information about or from distributed energy resources (DERs), information about customers, and threat and vulnerability information. The most important aspect to consider is whether new vulnerabilities are emerging as a result of increased interaction with DERs and whether there are barriers to sharing the existence of such vulnerabilities through utility–Electricity Information Sharing and Analysis Center (E-ISAC) information exchange. Since most DERs are customer-owned, utilities generally do not direct how these assets should be operated or secured. As such, they may be treated as untrusted entities. As vulnerabilities inevitably arise on DERs and grid-connected IoT (internet of things) devices in general, safeguard policies such as least privilege and role-based access form the first line of defense. If vulnerabilities do arise, they would be associated with a device or class of devices, and would not be associated with customer personally identifiable information, and so sharing through forums like utility–E-ISAC would not be impaired.

Q7. During the Energy Subcommittee hearing on September 14, you commented that improving the interruption cost estimation calculator, CAIDI, SAIDI, SAIFI, and other tools would be valuable. Are there specific changes to these that you would recommend? For example, do you believe these metrics undervalue the impact of large-scale events and economic damage?

A7. The System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and Customer Average Interruption Duration Index (CAIDI) are reliability indices in widespread use across the electric industry to measure the physical dimensions of power interruptions: how long and how many times electric customers are without power.[1] These are typically used to measure the frequency and duration of outages averaged over the course of a year. They have been reported by electric utilities

[1] SAIFI is the average annual sustained interruptions per customer, calculated as the total number of sustained interruptions in a year divided by the total number of customers in the system. SAIDI is the average annual interruption duration per customer, calculated as the total duration of sustained interruptions in a year divided by the total number of customers in the system. CAIDI is the average interruption duration, calculated as the total duration of sustained interruptions in a year divided by the total number of interruptions in the system.

to public utility commissions for decades to ensure adequate planning and grid maintenance in order to maintain reliability under all but the most extreme and unpredictable circumstances. Measuring resilience involves applying similar metrics, but for individual events that occur during the year. These events, characterized typically as being low-frequency, high-impact occurrences, may be represented by major storms that would cause power outages for many hours or several days. The reliability indices, however, do not provide information on the causes of outages or who is affected by them.

The Interruption Cost Estimation (ICE) Calculator is used to determine the cost of power interruptions. The ICE Calculator currently relies on 34 utility-sponsored surveys conducted by 10 utilities that gathered data directly from utility customers on the costs of power outages. However, the surveys are, in some cases, over 20 years old and do not represent many regions of the country. In addition, the data applied by the tool are applicable mainly to short-duration events: a day or less. However, given that the ICE Calculator contains the best information on losses due to power interruptions, many practitioners apply the tool to weigh options for improving resilience. When examining such options, the ICE Calculator can provide estimates of avoided costs from the various efforts being considered for reducing the frequency or duration of outages. The estimated avoided costs can then be examined against the costs of the proposed improvements to determine the most effective solutions from a cost-benefit or value analysis.

However, surveys alone are insufficient to determine the cost of large-scale, long-term events. Such cost determinations involve estimates of economic and societal losses that consider macroeconomic effects, such as supply chain issues or impacts to public health and safety. Approaches and modeling tools exist to undertake such analyses, but they may be cumbersome, computationally intensive, or reliant upon unavailable data. These approaches also require the application of risk-based methods that can examine the cost and benefits of various options based on the estimated probability of threats and their consequences. Metrics and the underlying data to enable risk-based approaches include:

- Establishing resilience objectives at local, State, regional or national levels, as efforts to improve resilience may be costly or need to be customized for particular circumstances,

- The probability of threats related to weather or other causes,
- The vulnerability of infrastructure to various threats,
- The magnitude of consequences (such as impacts to health, productivity and property) when infrastructure becomes vulnerable to threats,
- The cost of implementing mitigation strategies to improve restoration time and for making infrastructure less vulnerable, such as hardening assets, and
- Reductions in outage duration and associated macroeconomic costs due to mitigation efforts and infrastructure upgrades to limit vulnerability and consequence.

The Department is currently developing a risk-based methodology and applying it in limited circumstances, as well as examining accompanying metrics and data requirements for resilience. These efforts are documented in a recent report issued by the Grid Modernization Laboratory Consortium.[1]

Q8. There is an ever-increasing amount of distributed generation and behind-the-meter technologies and market structures being deployed across the grid. How does additional behind-the-meter activity at the distribution level potentially affect the bulk power system? Is behind-the-meter information and data being shared between utilities, state regulators, and federal entities – including FERC, NERC, and DOE? Are there areas for improvement?

A8. Distributed generation and behind-the-meter technology at the distribution level, when it becomes aggregated to a sufficient size, can impact both the planning and operations of the bulk power system (BPS), both of which are essential to maintain grid reliability. When these distribution-level activities were small enough not to have significant BPS effects, they could be ignored by BPS planners and operators. Today, because of their growth in some regions, estimates of the type and amount of such demand-side resources are important to include in grid planning to make sure sufficient bulk power generation with necessary reliability attributes and transmission are built. Informed estimates of the type and magnitude of these demand side resources are now routinely included in BPS

[1] See Grid Modernization Metrics Analysis (GMLC1.1), Reference Document, Version 2.1, May 2017, Grid Modernization Laboratory Consortium, which is available at: https://gridmod.labworks.org/sites/default/files/resources/GMLC1%201_Reference_Manual_2%201_final_2017_06_01_v4_wPNNLNo_1.pdf

planning at utilities that conduct integrated resource planning, as well as by centrally-organized wholesale market operators (regional transmission operators and independent system operators). Estimates have been made for energy efficiency and demand response, and now are being done in some regions of the country, such as California, Arizona, and Hawaii, for distributed generation when significant in size.

For day-to-day bulk power system operations, behind-the-meter activities of sufficient aggregated size must be taken into account to maintain BPS reliability. Some grid operators tap these resources to their advantage, such as dispatching aggregated distribution level demand response as an economic alternative to generation. However, for areas experiencing rapid growth in distributed generation and where sizeable amounts are in use, BPS grid operators are expressing reliability concern about not having real-time knowledge, or visibility, of distributed generation that is operating.[1] The utility industry, vendors, and DOE are all working to develop the technologies and control systems required to provide visibility for grid operators. Capabilities to enable additional visibility of behind-the-meter assets can be accomplished incrementally beginning with simple efforts to determine the location and character of those assets, improving planning and operational coordination among asset owners, distribution operators, and transmission operators, and finally deploying more sophisticated sensing and control technologies.

Requirements for installation of visibility-providing technologies, such as smart inverters for roof-top solar, would have to come from states, who have jurisdiction under the Federal Power Act for distribution of electricity. The North American Electric Reliability Corp. (NERC), the entity legally responsible for ensuring bulk power system reliability, cannot make such requirements.

[1] "Visibility and controllability of these resources…are essential to reliably plan and operate the bulk power system." NERC remarks at February 4, 2016 Public Input Meeting of the Quadrennial Energy Review, Washington, DC https://www.energy.gov/sites/prod/files/2016/02/f29/Panel%201%20Gerry%20Cauley%2C%20President%20%26%20CEO%2C%20North%20American%20Electric%20Reliability%20Corp..pdf.

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October 30, 2017

Mr. Gerry Cauley
President and CEO
North American Electric Reliability Corporation
1325 G Street, N.W.; Suite 600
Washington, DC 20005

Dear Mr. Cauley

Thank you for appearing before the Subcommittee on Energy on Thursday, September 14, 2017, to testify at the hearing entitled "Part 1: Powering America: Defining Reliability in a Transforming Electricity Industry."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Monday, November 13, 2017. Your responses should be mailed to Allie Bury, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Allie.Bury@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

Attachment—Additional Questions for the Record

The Honorable Fred Upton

1. **In your testimony you mention that conventional baseload such as coal and nuclear plants – provide frequency support services as a function of their large spinning generators.**

    a. **What are some of the consequences to deviations in frequency?**

As your question suggests, a reliable bulk power system requires maintaining synchronous generation. The electric grid is designed to operate at a frequency of 60 hertz (Hz). Deviations from 60 Hz can have destructive effects on generators, motors, and equipment of all sizes and types. It is critical to maintain and restore frequency after a disturbance such as the loss of generation. This requires an instantaneous (inertial) response from some resources and a fast response from other resources to slow the rate of fall during the arresting period, a fast increase in power output during the rebound period to stabilize the frequency, and a more prolonged contribution of additional power to compensate for lost resources and bring system frequency back to the normal level.

    b. **Do retirements of conventional baseload units impact frequency?**

Conventional generation units have operating characteristics that can provide essential reliability services necessary for reliable operation of the bulk power system (BPS). As the generation resource mix evolves, the reliability of the electric grid depends upon the operating characteristics of the replacement resources. Specifically, new resources coming online should have the ability to contribute to frequency control of the system.

As conventional generation retires, governor response may decline as the share of variable generation on the system increases. It is common for conventional generators to operate below their maximum rated output, allowing for some governor modulation. This allows the generators to have some flexibility in the upward direction and help support the interconnection response to frequency deviations in a timely manner. Overall, an operating area requires complete capability to manage frequency control for stable system operation.

Simulations of modern wind power plants have demonstrated improved frequency control by implementing fast response to an event at the cost of reducing a portion of its real-power production. Specific levels of frequency response reserves need to be modeled, analyzed, and incorporated in future planning and operating criteria. Specific levels of such support for varying resource mixes will need to be established based on the dynamics of their respective interconnected systems.

c. What policies does NERC have to ensure frequency is consistent?

NERC has a suite of reliability standards that work together to ensure that the system has the ability to maintain a consistent frequency across the grid. NERC Reliability Standard BAL-002-2 requires generation grid operators (known as Balancing Authorities) to recover from a grid event within specified timeframes. The reliable operation of the interconnected power system requires that sufficient resources be available to continuously serve demand and provide contingency reserves that enable the system to respond quickly to lost capacity and energy resulting from forced outages of generation or transmission equipment. In addition, NERC Reliability Standard BAL-003-1 requires those same grid operators to maintain frequency. Frequency deviations are caused when load and generation are not balanced. These grid operators would need excess on-line capacity to make up for any loss of generation to keep the frequency equation in balance. Finally, NERC Reliability Standard EOP-011-1 addresses the effects of operating emergencies by requiring each transmission operator and balancing authority to develop an operating plan (or plans) to mitigate operating emergencies, and that those plans be coordinated between operators.

The Honorable Robert Latta

1. **In your testimony, you explain how NERC performs a critical role in real-time situational awareness and information sharing to protect critical electric infrastructure.**

    a. **Do you have examples of how this real-time situational awareness and has helped protect the grid?**

NERC, through both its Electricity Information Sharing and Analysis Center (E-ISAC) and Bulk Power System Awareness (BPSA) departments, maintains real-time situational awareness of conditions and events on the grid that inform NERC's and industry's efforts to protect critical infrastructure and assure reliability.

For example, through the Cybersecurity Risk Information Sharing Program (CRISP), the E-ISAC receives information from either the Department of Energy (DOE) or DOE's Pacific Northwest National Laboratory (PNNL) about anomalies or abnormalities they see in the CRISP data. From there, the E-ISAC is able to work closely with affected entities, DOE, PNNL, and other relevant organizations that can assist with analyzing the data received, identifying potential causes of the anomaly, developing mitigation strategies (if necessary) and communicating to the broader electricity community to monitor their systems for similar activity.

To date in 2017, CRISP has compared more than 18,000 high-value and not publically available threat indicators to data shared by CRISP participants. From those 18,000 indicators, the E-ISAC produced 213 reports that identified potentially suspicious activity. CRISP participants then investigated each report to correlate against internal cyber activity. This private-public partnership *provides a detailed understanding of the intrusion methods, aspirations, and technical proficiency that threat actors employ to evade detection and conduct computer network exploitation and attacks.*

CRISP also fosters collaboration among participants on the sharing of indicators of compromise (IOC). To date in 2017, 25% of the CRISP reports are based on information that CRISP participants share. These cases included targeted spear phishing campaigns, redirects to suspicious web pages, and other IOCs. This increased information sharing resulted in enhanced awareness and security for CRISP participants as well as the rest of the electricity industry.

In addition to E-ISAC activities, BPSA maintains real-time situational awareness of the operational status, significant events, and all-hazards threats to the four interconnections across North America. BPSA provides this operational context to E-ISAC as an input to its assessment of security risks to better tailor the E-ISAC's information sharing activities and focus ongoing analyses. Some examples of this interdepartmental collaboration include operational assessments in the hours following the 2013 Metcalf substation shootings that quantified the potential electrical impacts of the attack, "confirm-or-deny" consultations regarding the apparent causes of large customer outages or system disturbances, and triage of multiple simultaneous events to assess the possibility of a coordinated attack on the grid. BPSA also maintains an open line of communication with real-time system operating desks at each reliability coordinator organization to initiate or facilitate rapid information sharing at the "tip of the spear" as needed, as was done during a series of physical attacks on Entergy transmission infrastructure in Arkansas a few years ago.

The E-ISAC has and continues to work closely with cyber security leaders to release actionable information to electric industry companies. The E-ISAC collaborated with the SANS Industrial Control Team to release Defense Use Cases on the 2015 and 2016 cyber security events that impacted Ukraine's electric grid. Additionally, the E-ISAC worked closely with FireEye and DOE to release actionable cyber security information on an advanced persistent threat targeting the energy and nuclear sectors. The E-ISAC continues to collaborate with industry, government, and third-party cyber security organizations to develop and distribute information that electricity companies can use to inform their security postures.

2. **Can you talk more about the Critical Infrastructure Protection Standards that FERC and NERC have worked together on? Specifically, could you talk about the tiered approach to cybersecurity that utilities began to implement in 2016?**

By expressly stating in the Energy Policy Act of 2005 that reliability standards extend to "cybersecurity protection," Congress had the foresight to anticipate the emerging risk posed by cyber security threats to the bulk power system. NERC's critical infrastructure protection standards (CIP standards) have evolved over time as the nature of threats and vulnerabilities have become better understood. The CIP standards that are currently in effect apply requirements according to impact rating criteria that characterize the level of impact (high, medium, or low impact) of electrical assets, which, if destroyed, degraded, misused, or otherwise rendered unavailable, would affect the reliable operation of the Bulk Electric System. The CIP standards' requirements then *reference those impact categorizations in order to apply commensurately a risk-informed set of cybersecurity requirements. This approach offers increased flexibility in implementing risk mitigation to individual entity operations, enhancing the overall effectiveness of the standards.*

The Honorable Gregg Harper

1. **Last year, NERC issued a report which found that "areas with a growing reliance on natural gas-fired generation are increasingly vulnerable to issues related to gas supply unavailability." Can you explain the risks associated with gas supply unavailability?**

NERC recently released a special assessment examining impacts of natural gas supply interruptions, "Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System." This study as well as our past assessments note that an increasing reliance upon natural gas-fired generation raises important issues for fuel supply security and assurance. The risks are two-fold:

- *The first is **Interruption Risk**. When electric generator customers do not procure "firm" supply and transportation for their fuel, their service is likely to be interrupted when firm customers schedule their full entitlements—particularly in constrained pipeline areas such as New England.*
- *The second is **Curtailment Risk**, which occurs when "firm" service is disrupted through a force majeure event. Curtailments occur when facility outages impact the scheduled flow of natural gas for any reason.*

Understanding the distinction between these two risks is important due to their solutions being very different. For example, electric generation with "firm" fuel service agreements can still be curtailed but can be offset by dual-fuel capability, so long as the back-up fuel inventory is maintained and is not impacted by other issues (e.g., cold weather, for example, can affect the ability of generator to switch-over to a secondary fuel source).

Interruption Risk is generally considered in NERC's annual reliability assessments. Through the assessments, NERC puts a spotlight on generator availability risks that may be impacting their ability to meet peak seasonal demand. However, issues related to generator interruptions are likely to be resolved through integrated resource plans, state or provincial regulatory requirements, and implementation of mitigation strategies—such as dual fuel capability and electricity markets (where they exist). Each of these solutions has a mechanism to consider the reliability needs of the system.

This growing interdependence of the natural gas and electric infrastructure has resulted in new operational and planning reliability challenges. For example, the Aliso Canyon natural gas storage facility leak underscored not only the reliance on natural gas to meet electric demand but also how the disruption of a key natural gas infrastructure component can impact BPS reliability. In addition to natural gas storage, pipelines, compressor stations, and liquefied natural gas (LNG) facilities are *also critical components of the natural gas infrastructure that the electric industry relies on to meet its load-serving obligations. While the natural gas industry has demonstrated a high degree of reliability, the natural gas leak at Aliso Canyon raised awareness of the BPS's dependency on natural gas infrastructure and calls for a closer look at the facilities that support fuel deliveries to electric generation.*

<u>The Honorable Bill Flores</u>

1. **As you know, the rapid changes occurring in the generation resource mix and new technologies are altering the operational characteristics of the electricity system and are challenging system planners and operators.**

    a. **How does NERC, through its standards, tackle these challenges?**

NERC has a suite of reliability standards that work together to ensure that the system has the ability to maintain a consistent frequency across the grid. NERC Reliability Standard BAL-002-2 requires generation grid operators to recover from a grid event within specified timeframes. The reliable operation of the interconnected power system requires that sufficient resources is available to continuously serve demand and provide contingency reserves that enable the system to quickly respond to lost capacity and energy resulting from forced outages of generation or transmission equipment. In addition, NERC Reliability Standard BAL-003-1 requires those same grid operators to maintain frequency. Frequency deviations are caused when load and generation are not balanced. These grid operators would need excess on-line capacity to make up for any loss of generation to keep the frequency equation in balance. Finally, NERC Reliability Standard EOP-011-1 addresses the effects of operating emergencies by requiring each transmission operator and balancing authority to develop operating plan(s) to mitigate operating emergencies, and that those plans are coordinated between operators.

In addition, NERC annually reviews the changes in the resource mix with its Long-Term Reliability Assessment to identify potential trends in technology integration. Further, NERC is constantly evaluating events on the system to determine whether emerging technology is creating new reliability risks, and how those risks should be addressed.

The Honorable Jerry McNerney

1. **There's been discussion about the connection between markets and reliability and resiliency. Yet not all states regulators distinguish between reliability and resiliency.**

    a. **Do you believe states should make a distinction between the two?**

System resilience is becoming an enhanced yardstick of reliability. NERC defines reliable operation as "operating the elements of the BPS within equipment and electric system thermal, voltage, and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements."[1] NERC is willing to assist states as they consider resilience and reliability matters.

    b. **Does the electric sector use a standard definition of resiliency in both the distribution system and the bulk power system?**

The electric sector has no standard definition of resilience, however the National Infrastructure Advisory Council (NIAC) incorporates widely accepted concepts. The NIAC definition states, "Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event." NERC would also stress that resilience is already built into many of NERC's efforts, including the importance to learn from events.

    c. **Are there potential benefits to having a more industry-wide accepted term or definition for resiliency?**

There are many different factors to consider. NERC's Board of Trustees recently asked the Reliability Issues Steering Committee to review how NERC's mission currently incorporates resilience of the bulk power system, consider working definitions of resilience, and develop a framework for further discussion at the next NERC board meeting in February.

2. **Is there a standard training for NERC CIP auditors, regardless of the region in which they conduct audits? Has NERC received comments from multi-state IOUs regarding discrepancies in findings, audit results, and interpretations related to CIP compliance?**

NERC provides common training to all auditors, regardless of region, including courses on auditing principles, standards-specific information, and ongoing technical training. NERC provides these in face-to-face settings and through computer-based learning systems. Additionally, NERC facilitates information sharing among CIP auditors through a formalized working group tasked with developing and supporting consistent audit processes. To identify and address any perceived inconsistency, NERC monitors each regional entity's adherence to the regional delegation

[1] *See Glossary of Terms Used in NERC Reliability Standards.*

agreements, the NERC Rules of Procedures, and NERC guidance, as well as policies and procedures. Additionally, NERC administers the ERO Enterprise Program Alignment Process which allows industry to report perceived consistency issues and NERC will track, triage, and resolve consistency issues (this process also allows submitters to remain anonymous).

3. **How can NERC and industry stakeholders improve the number of participants in GridEx?**

NERC's E-ISAC has conducted its biennial Grid Security Exercise (GridEx) series since 2011. Since that time, industry and government stakeholders have demonstrated their commitment to continuing and growing their participation in GridEx. GridEx III in 2015 included 4,400 participants from 365 organizations; this year, GridEx IV had over 6,200 participants from 416 organizations from across industry, the US, state, and local governments, Canada, and Mexico.

The E-ISAC conducted extensive outreach to industry and government at conferences, working group meetings, and through webinars. GridEx received support from major industry trade associations such as the American Public Power Association, the Edison Electric Institute, and the National Rural Electric Cooperative Association, the National Emergency Managers Association, and the National Governors Association. In addition, the E-ISAC worked through cross-sector ISACs to encourage members to participate in GridEx, and we saw direct recruiting of utilities by other utilities. For GridEx IV, cross-sector participants included representatives from the Communications industry, the financial services sector, the downstream natural gas sector, and the water sector.

In addition to this outreach, the E-ISAC continually adds value to the voluntary exercise through an extensive volume of cyber and physical training materials and credit toward cyber and physical certifications for individuals as well as organizational benefits toward compliance requirements such as updating and exercising crisis response plans. The relationships built between electric utilities and local, state, provincial, and federal government departments and agencies is an additional draw toward ever-increasing participation in the extreme cyber and physical attack scenarios.

4. **Is there information on what causes outages or power disruptions – whether it's a squirrel, cyber-attack, fallen tree, etc.?**

Severe weather is the most common cause of bulk electric system (BES) events. Equipment failure in ways unanticipated by design, as well as human error, are other observed factors. NERC's event analysis process assigns appropriate levels of analysis to determine the causes of BES events, promptly assuring tracking of corrective actions to prevent recurrence, and providing lessons learned to the industry. The NERC event analysis process also provides valuable input for training and education, reliability trend analysis efforts, and reliability standards development, all of which support continued reliability improvement. NERC's report – State of Reliability 2017 – provides a detailed and comprehensive analysis of the performance of the BES. This report is produced annually, analyzing the historical risks to the BES with a view toward developing a risk-based approach to solving important Bulk Electric System problems.

5. **How can we properly recognize and value interdependency and cross sector security between oil and gas industries and the electric sector?**

Given the dynamic nature of security threats, cross-sector collaboration is essential. Recognizing interdependencies, the E-ISAC works across many sectors through formal and informal partnerships at both the policy and operational levels.

The E-ISAC participates in daily cross-sector coordination calls with other ISACs to maintain situational awareness of current threats. In addition, E-ISAC staff participate in meetings and coordination with the National Council of ISACs, which provides a forum for sharing cyber and physical threats and mitigation strategies.

In 2017, NERC and the American Gas Association launched a new grid and energy delivery security partnership that takes advantage of the growing interdependency and collaboration of the natural gas and electricity industries. Under the partnership, staff from the Downstream Natural Gas Information Sharing and Analysis Center (DNG-ISAC) joined the E-ISAC in Washington, D.C., to improve coordination on potential security risks related to critical electricity and natural gas pipeline infrastructure. The partnership between the E-ISAC and the DNG-ISAC builds on the long-standing efforts of the gas and electricity industries to address supply interdependencies by developing a robust information exchange on shared security risks.

Finally, NERC is a member of the Electricity Subsector Coordinating Council, which facilitates executive-level coordination between the electricity industry and government officials at the highest levels.

6. **With limited resources, how can we prioritize and identify what to make resilient on the electric grid?**

The production, transmission, and use of electric energy by consumers are dramatically changing. Historically, the system was characterized by centralized dispatch of large synchronous generation and transmission of that power over long-distances to meet customer needs. Currently, the system is moving toward a hybrid model that integrates distributed energy resources and larger amounts of variable renewable resources. The potential impact of these changes must be considered to ensure a reliable and resilient BPS.

Among other initiatives, NERC's Reliability Issues Steering Committee (RISC) identifies and prioritizes many potential risks and makes recommendations to maintain a reliable and resilient BPS. The RISC undertakes a comprehensive review of existing and evolving reliability risks, respective priorities, and evolving character of industry dynamics. It also gathers wide and diverse inputs from industry leaders, associated stakeholder groups, and the regulatory arena. The RISC has convened several Reliability Leadership Summits and a wide-ranging series of focused executive interviews to provide further confidence that key existing and evolving risks to BPS reliability have been identified and captured with no significant issues overlooked. This approach has included resiliency considerations, and has recommended additional industry analysis of common mode failures (e.g. fuel supply failures, extreme weather, transmission corridor outages, *cyber-attacks, cold weather preparation). Industry has responded by participating in cold weather preparation seminars, industry-wide table top exercises on cyber/physical security, and supporting the work plans from the NERC technical committees developed to address evolving and emerging risks to reliability.*

7. **What barriers exist for utilities and for the federal government as it relates to utilities sharing resources during emergencies, such as hurricane response?**

The electric power industry maintains a robust and highly effective mutual assistance network which significantly enhances the industry's response and restoration process. Industry and government continue to examine ways to address barriers and further enhance efficient resource sharing. Because the mutual assistance program is exclusive to industry, individual asset operators and their respective trade associations are best positioned to address this important question.

8. **What are the three most common CIP violations, and how often did those occur in 2016?**

Over the past three years, covering 2015, 2016, and 2017 thus far, critical infrastructure protection standards with the highest incidence of noncompliance involved CIP-007 (system security management), CIP-006 (physical security of bulk electric system cyber systems), and CIP-004 (personnel training). NERC's enforcement process assesses the level of risk posed by each instance of noncompliance. Accordingly, it is important to stress that in the vast majority of cases (86%), these instances of noncompliance were assessed to be of minimal risk. 13.4% were of moderate risk; and 0.5% were of serious risk.

9. **To what extent has the increased utilization of distributed energy resources, IoT devices, and other smart grid resources affected the potential sharing of customer data that that is potential threat and vulnerability information as it relates to utility-EISAC information sharing?**

The E-ISAC and NERC do not receive customer data, only information from utilities about potential and confirmed security-related issues detected on their systems. At the customer-utility boundary, distributed energy resources, Internet of Things, and smart grid resources offer new ways for utilities to understand better the issues their customers face, as well as improve efficiency in operations. Aggregated analysis can be voluntarily shared with the E-ISAC but will never contain information about specific customers. In general, these new technologies will certainly help utilities better understand potential and emerging threats, which in turn, help them provide more accurate voluntary reporting to the E-ISAC. The E-ISAC also released an alert in 2016 on the use of IOT devices for high bandwidth denial of service attacks, and in 2017 on supply chain risks.

10. **There is an ever-increasing amount of distributed generation and behind-the-meter technologies and market structures being deployed across the grid. How does additional behind-the-meter activity at the distribution level potentially affect the bulk power system? Is behind-the-meter information and data being shared between utilities, state**

regulators, and federal entities – including FERC, NERC, and DOE? Are there areas for improvement?

As more resources move behind-the-meter to the distribution system and behind the meter, it is increasingly important for planners, operators, and balancing authorities to have visibility into how these resources could affect reliable operation of the BPS. In certain areas, distributed energy resources (DER) are numerous and embedded within a distribution system that has traditionally been viewed as a relatively passive load resource on the BPS. This will no longer be a valid assumption with the integration of more DER on the electric system. There are at least two major events that have occurred on the European power system where the disconnection of DER played a role in system collapse.[2]

In addition, newer DER technologies are capable of providing advanced support services that will be needed as the transition from conventional synchronous resources to nonsynchronous inverter-based resources continues. It is paramount that NERC and the industry understand DER functionality and develop a set of guidelines to assist in modeling and assessments such that owners/operators of the BPS can evaluate and model DER in the electric system. In support of this priority, NERC is developing a set of guidelines to assist in modeling and performing assessments such that owners/operators of the BPS can evaluate and model DER in the electric system. Two guidelines have already been developed and additional guidelines are expected to be completed by mid-year 2018: These can be found at: http://www.nerc.com/comm/Pages/Reliability-and-Security-Guidelines.aspx

Data requirements and information sharing across the transmission-distribution interface should also be further evaluated to allow for adequate assessment of future DER deployments. NERC reviews these issues in a recent report, Distributed Energy Resources: Connection Modeling and Reliability Considerations.

[2]**Italy Blackout 2003:** On the 28th September 2003, a blackout affected more than 56 million people across Italy and areas of Switzerland. The disruption lasted for more than 48 hours as crews struggled to reconnect areas across the Italian peninsula. The reason for the blackout was that during this phase the under-voltage load shedding (UVLS) could not compensate the additional loss of generation, when approximately 7.5 GW of distributed power plants tripped during under-frequency operation. **European Blackout 2006:** In the night of 4 November 2006, at around 22:10, the UCTE interconnected grid was affected by a serious incident originating from the North German transmission grid that led to power supply disruptions for more than 15 million European households and a splitting of the UCTE synchronously interconnected network into three areas. The imbalance between supply and demand as a result of the splitting was further increased in the first moment due to a significant amount of tripped generation connected to the distribution grid. In the over-frequency area (North-East), the lack of sufficient control over generation units contributed to the deterioration of system conditions in this area (long lasting over-frequency with severe overloading on high-voltage transmission lines). Generally, the uncontrolled operation of dispersed generation (mainly wind and combined-heat-and-power) during the disturbance complicated the process of re-establishing normal system conditions.

POWERING AMERICA: DEFINING RELIABILITY IN A TRANSFORMING ELECTRICITY INDUSTRY, PART 2

TUESDAY, OCTOBER 3, 2017

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

The subcommittee met, pursuant to call, at 2:07 p.m., in room 2123, Rayburn House Office Building, Hon. Fred Upton (chairman of the subcommittee) presiding.

Members present: Representatives Upton, Olson, Shimkus, Latta, Harper, McKinley, Kinzinger, Griffith, Flores, Mullin, Cramer, Walberg, Walden (ex officio), Rush, McNerney, Peters, Green, Castor, Sarbanes, Tonko, Loebsack, Schrader, Kennedy, and Butterfield.

Staff present: Ray Baum, Staff Director; Allie Bury, Legislative Clerk, Energy/Environment; Kelly Collins, Staff Assistant; Zack Dareshori, Staff Assistant; Wyatt Ellertson, Research Associate, Energy/Environment; Theresa Gambo, Human Resources and Office Administrator; Tom Hassenboehler, Chief Counsel, Energy/Environment; Jordan Haverly, Policy Coordinator, Environment; A.T. Johnston, Senior Policy Advisor, Energy; Mary Martin, Deputy Chief Counsel, Energy/Environment; Drew McDowell, Executive Assistant; Alex Miller, Video Production Aide and Press Assistant; Brandon Mooney, Deputy Chief Energy Advisor; Mark Ratner, Policy Coordinator; Peter Spencer, Professional Staff Member, Energy; Jason Stanek, Senior Counsel, Energy; Madeline Vey, Policy Coordinator, Digital Commerce and Consumer Protection; Evan Viau, Legislative Clerk; Hamlin Wade, Special Advisor for External Affairs; Everett Winnick, Director of Information Technology; Andy Zach, Senior Professional Staff Member, Environment; Michelle Ash, Minority Chief Counsel, Digital Commerce and Consumer Protection; Jeff Carroll, Minority Staff Director; Lisa Goldman, Minority Counsel; Dino Papanastasiou, Minority GAO Detailee; Caroline Paris-Behr, Minority Policy Analyst; and Tim Robinson, Minority Chief Counsel.

Mr. UPTON. Good afternoon, everyone. This is Part II of "Powering America: Defining Reliability in a Transforming Electricity Industry."

And so we have already done our opening statements. We did them a couple days ago, so we are going to turn to you. I just want to welcome all of you for joining us here today, and thanks again for your flexibility in rescheduling this very, very important hearing.

Today, we are going to reconvene with Part II of the Energy Subcommittee's hearing entitled "Powering America: Defining Reliability in a Transforming Electricity Industry."

The second panel of witnesses will provide their insight into how the different attributes of generation resources help system operators protect the reliability of the electricity grid. Especially in light of Friday's announcement this hearing is particularly timely. We are anxious to hear your thoughts.

As you know, your statements have been made part of the record in their entirety and so, if you would take no longer than 5 minutes each, and then we will do questions from the subcommittee.

Mr. Durbin, we will start with you, the executive VP and chief strategy officer of API, American Petroleum Institute. Welcome.

STATEMENTS OF MARTY DURBIN, EXECUTIVE VICE PRESIDENT AND CHIEF STRATEGY OFFICER, AMERICAN PETROLEUM INSTITUTE; PAUL BAILEY, CHIEF EXECUTIVE OFFICER, AMERICAN COALITION FOR CLEAN COAL ELECTRICITY; MARIA G. KORSNICK, CHIEF EXECUTIVE OFFICER, NUCLEAR ENERGY INSTITUTE; THOMAS C. KIERNAN, CHIEF EXECUTIVE OFFICER, AMERICAN WIND ENERGY ASSOCIATION; STEVE WRIGHT, GENERAL MANAGER, CHELAN COUNTY PUBLIC UTILITY DISTRICT NO. 1, ON BEHALF OF THE NATIONAL HYDROPOWER ASSOCIATION; CHRISTOPHER MANSOUR, VICE PRESIDENT, FEDERAL AFFAIRS, SOLAR ENERGY INDUSTRIES ASSOCIATION; KELLY SPEAKES–BACKMAN, CHIEF EXECUTIVE OFFICER, ENERGY STORAGE ASSOCIATION; AND JOHN MOORE, SENIOR ATTORNEY AND DIRECTOR OF THE SUSTAINABLE FERC PROJECT, NATURAL RESOURCES DEFENSE COUNCIL

STATEMENT OF MARTY DURBIN

Mr. DURBIN. Thank you, Mr. Chairman, members of the subcommittee, and thanks for the opportunity to testify today on the reliability of our electric grid.

Increased use of natural gas in electric power generation has not only enhanced the reliability of the overall system, it's also provided significant environmental and consumer benefits.

The abundance, affordability, low emissions profile, and flexibility of natural gas and natural gas-fired generating units make it a fuel choice.

There is no question, however, that the bulk power system will continue to rely on multiple fuels including natural gas, nuclear, coal, hydro, wind, solar, et cetera.

For those who believe diversity—fuel diversity is important for grid reliability, the good news is that the Nation's electric power generation portfolio is far more diverse today than it was a decade ago, largely due to the increased use of affordable reliable natural gas.

Government forecasts show that that diversity will be maintained for years to come. However, it's important to remember that fuel diversity in and of itself does not equal reliability.

Reliability is derived from a diversity of attributes and generation, not just the diversity of fuel sources. PJM's March 2017 report, "Evolving Resource Mix and System Reliability," notes "more diverse fuel portfolios are not necessarily more reliable."

That said, in every meaningful way, the inherent attributes of natural gas fuel generation including dispatchability, security of fuel supply, shorter start times, frequency response, quicker ramp rates, and lower minimum load level, to name a few, make the electric grid more reliable and resilient.

It's important, however, that market rules remain fuel neutral by assigning value to performance-based attributes that contribute to the reliability and resilience of the grid, rather than any particular fuel or technology.

Looking ahead, as the committee examines how best to ensure the long-term reliability and resilience——

Mr. UPTON. Mr. Durbin, even though I can hear you fine, can you just move the mic a little bit closer to you?

Mr. DURBIN. Yes, sir.

Mr. UPTON. Great. Thank you.

Mr. DURBIN. As the committee examines how best to ensure the long-term reliability and resilience, five factors are essential.

First, as I said a moment ago, natural gas generation enhances the flexibility of the electric grid by providing flexible and fast ramping, which can cycle off and on in a short period.

This helps maintain stability and reliability of the grid as it accommodates an increase in variable renewable energy resources.

Second, Government and private-sector experts are in agreement that natural gas will remain an abundant and affordable fuel for decades to come.

Third, because natural gas-fired power plants are one of the most cost effective forms of generation to build and operation, wholesale electricity costs have been significantly reduced.

As an example, since 2008 average annual wholesale power prices in PJM have decreased by almost 50 percent.

Fourth, the increased use of natural gas and power generation continues to drive emissions reductions. In 2016, carbon dioxide emissions for electricity generation were at nearly 30-year lows and EIA attributes 60 percent of the power-related CO2 emissions reductions since 2005 to a greater use of natural gas.

Finally, the geographic diversity of the natural gas system, where it is produced, and how it is transported makes it a reliable and resilient fuel source.

Market forces and public policy are driving the ongoing shift in our Nation's power generation mix. Natural gas generation is an important and growing part of that mix.

Collectively, the environmental advantages, reliability, and affordability of natural gas and natural gas generation have allowed it to earn its market share in the power generation space because it provides and will continue to provide reliable low-cost fuel for electricity generation and cost savings to consumers.

The natural gas industry stands ready to work with all stakeholders to ensure our Nation's electric grid is reliable, safe, and resilient. We were pleased to join more than a dozen other energy trade associations in a letter to this committee supporting competitive market rules that promote a diverse portfolio through fuel-neutral policies.

Thank you for the opportunity to testify today and I look forward to these questions.

[The prepared statement of Mr. Durbin follows:]

AMERICAN PETROLEUM INSTITUTE

Congress of the United States, House of Representatives
Committee on Energy and Commerce
Subcommittee on Energy

"Part II: Powering America: Defining Reliability in a Transforming Electricity Industry"

Testimony of:
Marty Durbin, Executive Vice President and
Chief Strategy Officer
American Petroleum Institute
October 3, 2017

Chairman Upton, Ranking Member Rush and members of the subcommittee, thank you for the opportunity to testify today. My name is Marty Durbin, and I am Executive Vice President and Chief Strategy Officer for the American Petroleum Institute (API).[1] The increased use of natural gas in electric power generation has not only enhanced the reliability of the overall system, but it has also provided significant environmental and consumer benefits. The abundance, affordability, low-emissions profile and flexibility of natural gas and natural gas-fired generating units make natural gas a fuel of choice. API understands that the bulk power system will continue to rely on multiple fuels, including natural gas, nuclear, coal, hydro, wind and solar, as projected by the Energy Information Administration.

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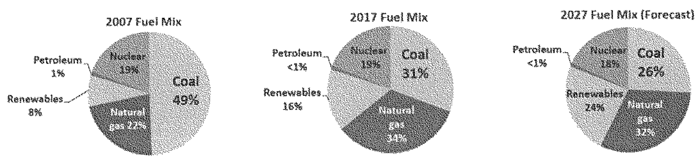
[1] API is the only national trade association representing all facets of the oil and natural gas industry, which supports 10.3 million U.S. jobs and nearly 8 percent of the U.S. economy. API's more than 625 members include large integrated companies, as well as exploration and production, refining, marketing, pipeline, and marine businesses, and service and supply firms. They provide most of the nation's energy and API member operations, and investments have added billions of dollars in economic value throughout the nation.



Source: 2017 Annual Energy Outlook, U.S. Energy Information Administration

We also agree that energy policy should be focused on ensuring the reliability and resilience of the nation's electrical grid at a reasonable cost, which reason and research tell us can be best achieved by allowing markets to determine the fuel mix of the generation portfolio.

What is Reliability?

Reliability means the continued operation of the electric grid and is achieved through adequate amounts of "essential reliability services" or "attributes," which keep the electric grid in balance. In general, however, reliability goes beyond just the operational aspects of the grid and extends to the entire national electric system and the ability of its constituent parts to operate. This includes long-term reliable access to fuel for generators, the stability of the fuel supply, the abundance of the resource supply, where it's sourced, the reliability of its production and transportation, and its long-term affordability.

Grid operators have the responsibility of maintaining the operational reliability of the electric grid. Generation owners are responsible for maintaining the integrity of their generating equipment and for ensuring they have adequate fuel supply contracts (and contracts for other operating supplies, such as water) and a portfolio of options in place so they have the ability to meet all their capacity and energy obligations under a wide range of scenarios. The natural gas industry has responsibility for ensuring the reliable operation of the natural gas supply chain and that customers receive their contracted commodity.

It is clear that natural gas generation has exceptional performance characteristics and attributes that can provide a full range of essential reliability services needed by the electric grid to maintain reliability. One important advantage of natural gas generation is its ability to ramp quickly and to cycle on and off in a short amount of time to meet the more rapidly changing levels of load due to increasing amounts of variable renewable energy resources on the grid. With respect to overall reliability, natural gas as a fuel supply is also exceptionally reliable, and the natural gas industry has a long history of providing reliable and continuous supplies to its customers, even in times of adversity, such as extreme weather events.

As noted in a report from the Massachusetts Institute of Technology:[2]

> *"The natural gas network has few single points of failure that can lead to a system-wide propagating failure. There are a large number of wells, storage is relatively widespread, the transmission system can continue to operate at high pressure even with the failure of half of the compressors, and the distribution network can run unattended and without power..."* [3]

In addition to pipeline contracts, dual-fuel capability, and other logistical factors, the geographically diverse production of natural gas and nationwide, interconnected pipeline network that transports the large majority of natural gas, significantly enhances system reliability and redundancy. Further, fuel supply risk is reduced as a result of numerous storage facilities across the nation. This extensive national network of natural gas storage facilities, many underground, makes them much less susceptible to extreme weather events and other natural disasters. Moreover, the existence of many operators, each

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[2] Natural Gas Council, Natural Gas Systems: Reliable & Resilient, July 2017, pages 6.

[3] *MIT, Lincoln Laboratory, "Interdependence of the Electricity Generation System and the Natural Gas System and Implications for Energy Security," May 15, 2013)*

making individual decisions, creates a diversity of operating practices and decisions, decreasing the likelihood of large-scale, multisystem outages.

Natural Gas Generation Is Reliable

With respect to the reliability attributes of generation facilities, a recent PJM system reliability study states "Portfolios composed of up to 86 percent natural gas-fired resources maintained operational reliability.[4] Thus, this analysis did not identify an "upper bound for natural gas."[5]

Reliability is derived from a diversity of attributes in generation, not a diversity of fuel sources. PJM's report notes, "More diverse [fuel] portfolios are not necessarily more reliable."[6]

Essential components of reliable supply resources include the ability for that resource to ramp up and down quickly; to keep pace with demand; to provide frequency response and reactive power to maintain grid stability; to provide energy consistently at baseload levels; to maintain fuel security through storage or transport contracts; to possess multiple sources of fuel; and to utilize domestically produced fuel. Natural gas generation provides all of these attributes. Figure 1 illustrates the reliability attributes of various resources.

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[4] PJM, "PJM's Evolving Resource Mix and System Reliability," March 2017
[5] Ibid
[6] Ibid

Figure 1. Reliability Attributes and Technology

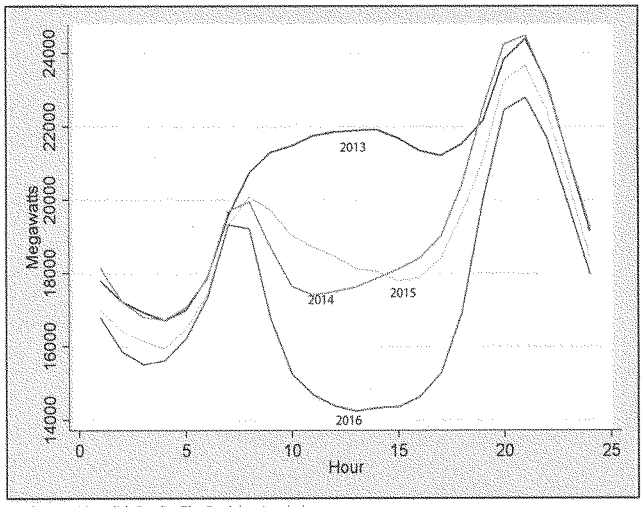
	Natural Gas - CC/CT/RICE/ Aeroderivate	Coal	Nuclear	Wind	Solar	Pondage Hydro	Run of River Hydro	Demand Response	Storage
Generation	●	●	●	●	●	●	●	N/A	N/A
Dispatchability	●	●	◍	○	○	●	○	●	●
Security of Fuel Supply	●	●	●	○	◍	●	◍	◍	◍
Start Times	●	○	○	N/A	N/A	●	N/A	●	●
Ramp Rates	●	◍	○	N/A	N/A	●	N/A	●	●
Inertia	●	●	●	◍	○	●	●	○	○
Frequency Response	●	◍	○	○	○	●	○	○	●
Reactive Power	●	●	●	◍	◍	●	◍	N/A	N/A
Minimum Load Level	●	◍	○	N/A	N/A	●	N/A	●	●
Black Start Capability	●	N/A	N/A	○	○	●	●	N/A	◍
Storage Capability	N/A	N/A	N/A	N/A	N/A	◍	N/A	N/A	●
Proximity to Load	●	◍	◍	◍	●	○	○	●	●

● Relatively Advantaged
◍ Neutral
○ Relatively Disadvantaged

Source: Brattle Group, Diversity of Attributes

A prime example of how ramping and cycling abilities are needed to maintain grid stability can be found in California. Figure 2 plots average net load profiles that have been averaged across seven days around March 31 to smooth out daily variations. Net load refers to load minus variable renewable generation and represents the load needed to be served by dispatchable generation. Due to the large amount of variable renewable generation, primarily solar, on the California grid, there is a frequent need for flexible dispatchable generation to be able to quickly ramp up and down in response to changes in net load, particularly when the sun starts to get low in the sky while the system is still in peak load conditions.

Figure 2. California Hourly Net Load - March 28 to April 3, 2013-2016



Source: Meredith Fowlie, The Duck has Landed.

Other regions are also starting to see higher penetrations of variable renewable energy resources and natural gas generation's flexibility will be increasingly needed to maintain grid reliability and stability.[7]

Natural Gas Supplies are Reliable and Resilient

Included in the appendix is a recent Natural Gas Council white paper highlighting the historical reliability of natural gas:

> **"The physical operations of natural gas production, transmission and distribution make the system inherently reliable and resilient. Disruptions to natural gas service are rare. When they do happen, a disruption of the system does not necessarily result**

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[7] Wind generation in ERCOT is reaching almost 40% of total demand at times; https://www.platts.com/latest-news/electric-power/houston/ercot-sets-record-wind-output-friday-21339374 and in SPP over 50%: https://www.spp.org/about-us/newsroom/spp-sets-north-american-record-for-wind-power/

in an interruption of scheduled deliveries of natural gas supply because the natural gas system has many ways of offsetting the impact of disruptions."[8]

The extensive national pipeline system prevents local disruptions, such as construction and maintenance or extreme weather events, from creating widespread disruptions. Also adding to the system's integrity and redundancy is the widespread use of compressor units powered by natural gas, rather than electricity, which significantly enhances the ability to move supply even during power outages.

Hurricane Harvey offers a clear example of the resiliency of the modern natural gas system. While natural gas systems were shut down in the Houston area and large parts of the gulf, the geographic diversity of the natural gas operations kept supplies flowing and prices stable. This is highlighted in the Bloomberg article included in the appendix and in Figure 3 below, which shows stable natural gas prices at several hubs for the weeks affected by Hurricane Harvey.

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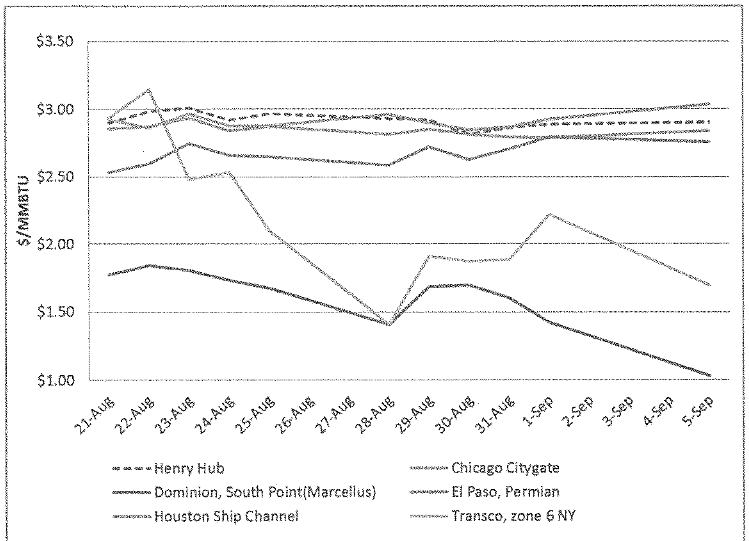
[8] Natural Gas Council, Natural Gas Systems: Reliable & Resilient, July 2017, pages 6.

Figure 3. U.S. Natural Gas Prices



Source: Platts

The Polar Vortex during the winter of 2014[9] is used by some as a cautionary tale against placing too much reliance on natural gas and an argument for increased on-site fuel. The fact, however, is that during the Polar Vortex, those with firm transportation contracts received their natural gas. It isn't commonly known that the limited incidents of natural gas supply interruptions were a result of interruptible contracts, not weather-related factors. The use of these contracts was an economic

[9] Polar Vortex-like events include: January 6th though January 9th, 2014; January 22nd through January 28th, 2014; February 9th through February 13th; and February 25th through February 28th, 2014

decision made by generation owners, not an indication of whether or not the natural gas supply infrastructure is reliable or not, as is often implied.[10]

The Polar Vortex winter presented broad challenges and was a learning experience for all forms of generation.[11] As a result, many regions took steps to ensure similar issues would not reoccur. For example, PJM developed its Capacity Performance plan, which requires generators to be able to deliver energy when emergency conditions exist. Generators are rewarded for meeting the increased standards for deliverability and are penalized when they do not. PJM puts a premium on resources that are dependable and available. As a result, more natural gas-fired plants have secured firm transportation contracts or added dual fuel capabilities to ensure reliability.

Government regulation and industry standards codify another layer of resiliency. The Transportation Security Administration (TSA) Pipeline Security Guidelines (Guidelines) support the development and implementation of a risk-based corporate security program by pipeline operators to address and document their organization's policies and procedures for managing security-related threats, incidents, and responses. The Guidelines include progressive security measures facilities may use, based on the characteristics of their particular facility and the threat level determined through their risk assessment. Under the guidelines, operators should develop and implement a corporate security plan customized to most effectively mitigate security risks to the company's critical assets. Such plans are comprehensive in scope; systematically developed; and risk-based, reflecting the security environment.

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[10] Partly, this economic decision was influenced by the inability of merchant generators to receive full cost recovery for higher priced firm transport contracts from the wholesale electricity markets. This issue has been and continues to be examined by the RTOs and FERC, and some pricing reforms have already been implemented.

[11] All types of generating units experienced outages for various cold-related issues, for example, frozen coal piles and cooling water systems. See PJM reports: https://www.gpo.gov/fdsys/pkg/CHRG-113shrg87851/html/CHRG-113shrg87851.htm and http://www.pjm.com/~/media/library/reports-notices/weather-related/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx

The many guidelines and standards that govern natural gas operators' management of cybersecurity include: TSA Pipeline Security Guidelines, National Institute of Standards and Technology (NIST) Framework for Improving Critical Infrastructure Cybersecurity, Department of Energy (DOE) Cybersecurity Capability Maturity Model (C2M2), ISA/IEC 62443 Series of Standards on Industrial Automation and Control Systems Security, INGAA Control Systems Cyber Security Guidelines, and API Standard 1164 Pipeline SCADA Security. Also, information sharing of cyber threats is another key defense through the Oil and Natural Gas Information Sharing and Analysis Center (ISAC) and through the Department of Homeland Security's National Cybersecurity and Communications Integration Center (NCCIC) and Industrial Control System Computer Emergency Readiness Team (ICS-CERT).

In addition, the National Critical Infrastructure Prioritization Program (NCIPP) categorizes high priority critical infrastructure as either level 1 or level 2 based on the consequences to the nation in terms of four factors—fatalities, economic loss, mass evacuation length, and degradation of national security. To date, no oil or natural gas assets are designated as level 1 (the highest level).[12] Additionally, the Presidential Policy Directive (PPD) 21 (2013) required the Department of Homeland Security to identify critical infrastructure "where a cybersecurity incident could reasonably result in catastrophic regional or national effects on public health or safety, economic security, or national security." The PPD 21 list of "Section 9 Critical Infrastructure at Greatest Risk" does not include any upstream natural gas companies or assets.[13] For a more detailed discussion of natural gas system reliability and resiliency, please see the recent Natural Gas Council white paper on the topic included in the appendix.

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[12] The list of L1/L2 infrastructure is classified, but the Department of Homeland Security has confirmed that no oil and natural gas assets are on the list.

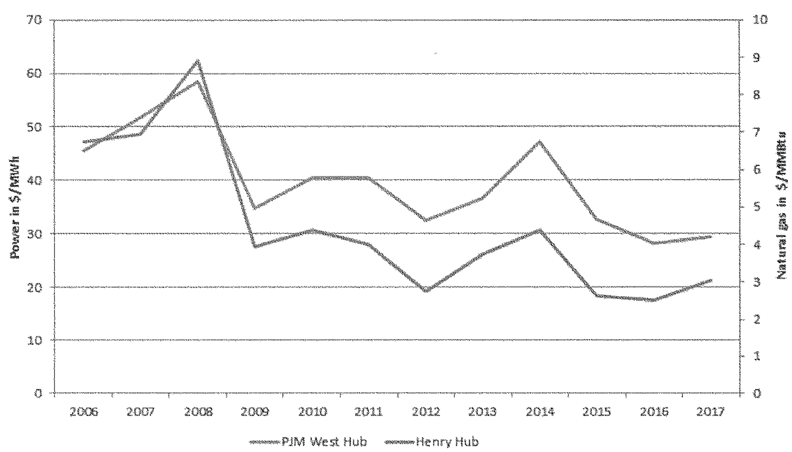
[13] The list of "Section 9" entities is classified; however, API is not aware of any member companies that are on the list.

Abundant Natural Gas Reduces Electricity Costs

Natural gas-fired power plants are one of the most cost-effective forms of generation to build and operate. This has resulted in significant wholesale electricity cost reductions. As an example, since 2008, average annual wholesale power prices in PJM have decreased by almost 50 percent. Market forces have driven these price reductions, thereby reducing costs for consumers and driving additional economic activity.

Figure 4 shows the PJM West Hub electricity prices along with Henry Hub natural gas prices over the past twelve years.

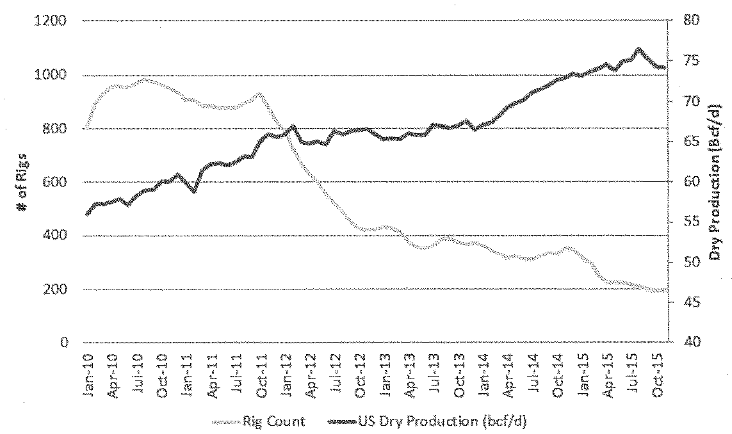
Figure 4. Wholesale Power and Natural Gas Prices



Source: NYMEX and ICE

Competitive markets work by eliminating inefficiencies in the system, thereby driving down prices for customers. Competitive forces in natural gas markets have resulted in the shale gas boom currently providing numerous benefits to the nation. Over the last decade, the natural gas industry has enhanced efficiencies and reduced costs. As shown in Figure 5, rig counts have fallen drastically while natural gas production has continued to rise. This is due to technological innovations driven by market competition. The same market forces simultaneously improve reliability and resiliency as those become necessary attributes in order to remain competitive.

Figure 5. Natural Gas Production Efficiency

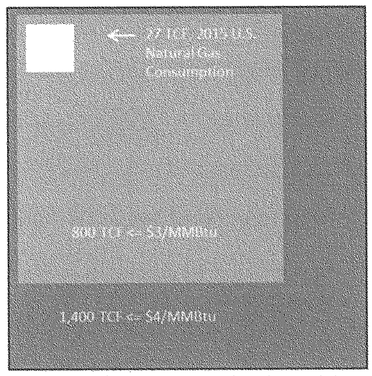


Source: EIA and Baker Hughes

These market-driven increases in efficiencies have resulted in extensive new supplies of natural gas being developed at lower prices than before, further increasing the reliability and resiliency of the supply.

The economics of lower commodity price production levels are measured in IHS-Markit's 2016 report "Shale Gas Reloaded: The Evolving View of North American Natural Gas Resources and Costs." The report identifies 1,400 Tcf of natural gas in the U.S. Lower 48 and Canada that is economically and technically recoverable at breakeven prices of $4/MMBTU with more than half (approximately 800 Tcf) of this resource base recoverable at prices of $3/MMBTU.[14]

Figure 6. Recoverable Reserves



Source: Data from EIA and IHS-Markit, February 2016

The size of IHS-Markit's resource base and their cost of recovery suggest two conclusions. First, there is sufficient natural gas to meet future demand, even when exports are taken into account. Specifically, the estimated production potential, even at the $3/MMBTU level (roughly 800 Tcf) dwarfs U.S. natural gas demand and expected exports. In 2015, total U.S. natural gas consumption was about 27 Tcf, and EIA forecasts natural gas consumption to range between 32.27 Tcf in the Reference Case to 38.33 Tcf by 2050 in the High Oil and Gas Resource and Technology (High Resource) scenario.[15] Adding natural gas exports to the story doesn't materially change the answer as those do not cross 1 Tcf in any scenario by 2050,[16] which is the last year of EIA's forecast.

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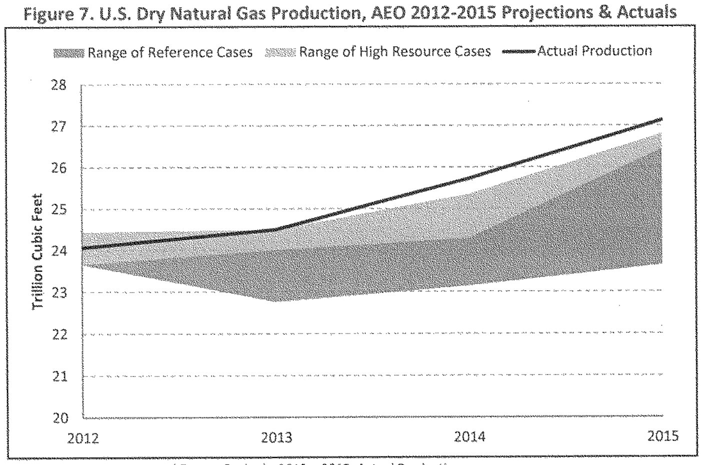
[14] IHS-Markit, "North America's Unconventional Natural Gas Resource Base Continues to Expand in Volume and Decrease in Cost." February 23, 2016.
[15] EIA Annual Energy Outlook 2016, Table: Energy Consumption by Sector and Source.
[16] Ibid

This massive supply figure and relatively low level of exports can, according to IHS, assuage any concerns about export demand pulling prices upward. Clearly, the U.S can be well positioned to be a critical global supplier of natural gas to our allies in Europe and elsewhere and can do so without affecting domestic affordability.

Second, the 800 Tcf of natural gas production that is economical in the \$3-\$4/MMBTU range (as shown in the IHS-Markit report) explains the sustained low price forecasts in the EIA Annual Energy Outlook's High Resource case. Because the industry has shown its ability to maintain, and even increase, high production levels in lower commodity price environments, the High Resource case price series showing sub \$4/MMBTU in the foreseeable future is likely the most representative of current market dynamics.

Each year, for the AEO, EIA conducts a base case analysis and then several alternative scenarios, one of which is the High Resource scenario. In the past few years, EIA has underestimated the impact of technology on natural gas production and the industry's ability to lower production costs. Consequently, the EIA has underestimated the size of the resource base in the High Resource case, as well as the Reference case. Figure 7 compares actual U.S. natural gas production to a range of EIA reference cases in previous AEOs as well as EIA's the High Resource scenario.

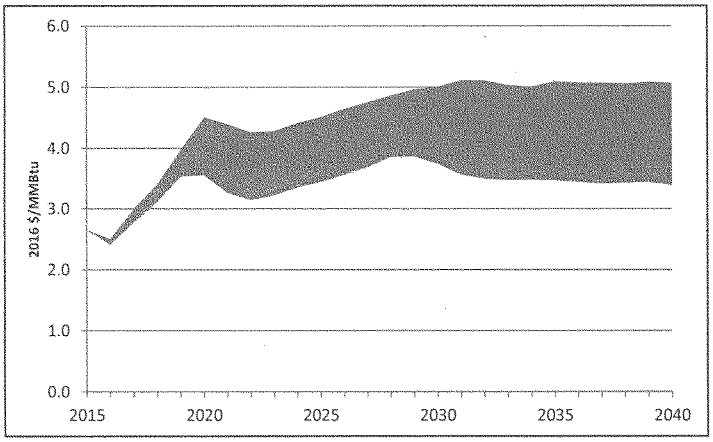
Figure 7. U.S. Dry Natural Gas Production, AEO 2012-2015 Projections & Actuals



Source: EIA, Annual Energy Outlooks 2012 – 2015; Actual Production

Figure 8 maps the corresponding price trajectories for both EIA's Reference Case and High Resource scenario (the former making the upper bound and the latter the lower bound of the chart). The lower bound of the series shows a steady natural gas price forecast within the $3-$4/MMBTU range, which has proven to be sustainable due to the industry's track record of reducing production costs.

Figure 8. EIA AEO 2017 Projection: Henry Hub Spot Price (Reference Case and High Supply Case Range)



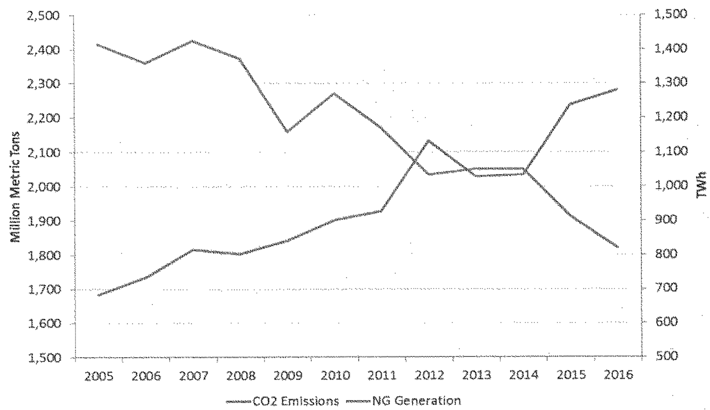
Source: EIA, Annual Energy Outlook, 2017

Natural gas is well positioned to provide a reliable and low-cost source of fuel for electric generation for the foreseeable future, according to both IHS and EIA, and many other natural gas resource base experts.

Natural gas abundance also reduces emissions. Total U.S. electrical sector emissions are down below 1990 levels mainly due to the influx of natural gas generation (1,831 million metric tons in 1990).[17]

[17] EIA

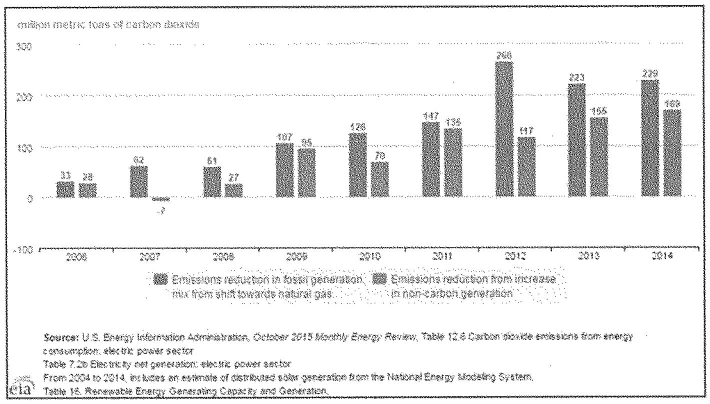
Figure 9. U.S. Electric Sector CO2 Emissions and Natural Gas Generation



Source: EIA, Monthly Energy Review August 2017

According to EIA data, 60 percent of the CO_2 reductions in the electric power sector from 2005 to 2016 have been the result of fuel switching from higher emission generation to natural gas generation. Figure 10 shows the emission reductions from US electric generation that can be attributed to two different economic responses. The blue bars are emissions reductions achieved through shifting from other fossil fuels to natural gas generation. The green shows emissions reductions from increases in non-carbon generation. It is evident from recent historical trends that both responses are important drivers for electric sector emissions reductions, and that natural gas has and will continue to lead the way as it has done while reducing costs to consumers and while increasing the supply base, all without substantial government subsidies.

Figure 10. Electric Sector CO2 Emissions Reductions



DOE Recommendations

Some of the recommendations in the recent DOE Staff Report on Electricity Markets and Reliability were directed at FERC, especially with regard to wholesale electricity market reforms. API has submitted comments to FERC dockets on numerous occasions, discussing the need to adapt wholesale electricity markets to the changing economics of the electric industry and the nature of the electric grid. The most recent comments were in response to a technical conference in May 2017 on state policies and these policies' effects on wholesale electricity market price formation. In those comments, API once again outlines a series of principles that should be adhered to in order to preserve and promote the much-needed and benefits-creating competitive nature of the wholesale electricity markets. These principles are:

- Efficient market design will result in price formation that matches the demand for essential reliability services and performance attributes with the supply.

- Energy market price caps should be lifted to a level sufficient to allow efficient price formation. Concurrent with this, FERC should require each RTO/ISO to settle all smart meters in its footprint on a five-to-fifteen minute basis, which would allow consumers and their retailers to react to the price information in the real-time market thus enhancing demand sector elasticity.
- Ideally, market-clearing prices should reflect the costs of all units that are called to operate, including start-up and no load costs.
- The market-clearing price should reflect the costs of all units that run including block-loaded or ramping units, operating reserves, units providing voltage support or reactive power, or units run in response to reliability events or needs.
- Prices in energy and ancillary service markets should reflect shortage or emergency situations to provide needed investment signals and to reinforce real-time reliability in the face of increased variable output of intermittent renewables.
- Price formation should enable all reasonable and supportable costs incurred in unexpected circumstances, particularly when such costs are incurred in response to operator directives.[18]

Much has already been done with respect to gas-electric coordination through the FERC's Natural Gas – Electric Coordination initiative.[19] All of the changes agreed to in that process by both the electric and natural gas industries have now been implemented. For example, the natural gas industry added additional opportunities for customers to access natural gas pipeline capacity throughout the day. Talks between the two industries continue to progress and, as mentioned earlier, it is important that any further changes are market-based and benefit from the free and competitive market nature of the natural gas system, and are fully supported by both industries.

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[18] Comments of the American Petroleum Institute, FERC Docket No. AD17-11-000, June 22, 2017.
[19] https://www.ferc.gov/industries/electric/indus-act/electric-coord.asp

Conclusion

Market forces, public policy, and environmental policy are driving the ongoing shift in our nation's power generation mix. Natural gas generation is an important and growing part of that mix. Collectively, the environmental advantages, reliability, and affordability of natural gas generation are unmatched by any other form of power generation. Natural gas has earned its market share in the electricity generation space and has provided, and can continue to provide, reliable, low-cost fuel for electricity generation and cost savings to consumers.

The natural gas industry stands ready to work with all stakeholders to ensure that our nation's electrical grid is reliable, safe, and resilient. We urge policymakers to recognize that a free and competitive market-based approach is the best way to ensure that our nation's electricity needs are met affordably, reliably and in the most environmentally responsible way possible.

Summary

Natural gas is a domestically produced, abundant, reliable and low-cost energy resource that lowers energy costs for consumers and spurs economic growth and opportunity for our nation. Natural gas enhances the reliability, decreases the cost, and lowers the environmental impact of the nation's electric system because:

- **Natural gas generation enhances the flexibility of the electricity grid.** Natural gas generation is flexible and fast ramping, and able to cycle off and on in a short period of time. This helps maintain stability and reliability on an electric grid increasingly experiencing net load volatility due to the increase in variable renewable energy resources.
- **Natural gas will remain a stable and low-cost fuel.** According to EIA, based on the past and expected future technical innovations, production growth, and the size of the resource, natural gas prices will remain stable and low for years to come, providing a reliable source of fuel for electric generation.
- **Natural gas' low cost helps to drive down wholesale electricity costs.** Low-cost natural gas continues to provide significant cost savings which may up free up funds for additional investment in other things, such as infrastructure, which, in turn, enhances reliability.
- **The increased use of natural gas in power generation has lowered emissions.** New, clean and efficient natural gas generation has grown considerably as a part of the electric generation mix, which has reduced electric sector emissions to levels not seen since 1990. In 2016, carbon dioxide emissions from power generation were at nearly 30-year lows.
- **The natural gas system is reliable and resilient.** Its geographic diversity in terms of supply provides for multiple flows in all directions across the country. Natural gas companies follow a rigorous set of

guidelines and standards and, due to the market-based nature of the industry, have a vested interest in keeping the product reliably flowing to all their customers.

Mr. UPTON. Thank you.

Mr. Bailey, president and CEO of American Coalition for Clean Coal Electricity, welcome. Nice to see you.

STATEMENT OF PAUL BAILEY

Mr. BAILEY. Chairman Upton, members of the subcommittee, we want to commend you for holding the hearing today and for allowing us the opportunity to testify.

ACCCE represents America's fleet of coal fuel power plants. Through the first half of this year, the fleet supplied 30 percent of the Nation's electricity needs.

In 2010, the coal fleet represented more than 300,000 megawatts of electric generating capacity. Unfortunately, more than 100,000 megawatts of coal fuel generating capacity have either retired or announced plans to retire.

These retirements represent one-third of the fleet that existed just 7 years ago. A secure electric grid is vital to the Nation's well-being. This means the electric grid must be both reliable and resilient.

The coal fleet provides many attributes that help ensure both reliability and resilience. These attributes include fuel security and many other essential reliability services.

It is important to keep in mind that reliability and resilience are not the same thing. Reliability refers to resource adequacy and the security of the bulk power system to withstand sudden disturbances, according the NERC.

Reliability is a well-defined term with agreed upon metrics and attributes. For example, my written testimony lists more than a dozen reliability attributes. The coal fleet scores well against these attributes. Some of the other resources represented on this panel also score well on reliability attributes.

On the other hand, there are no agreed upon resilience criteria or metrics. Resilience means maintaining a reliable grid in the event of a high-impact low-frequency events or, put another way, low probability disturbances that have catastrophic consequences such as a polar vortex.

Fuel security is critical to both reliability and resilience. Over the past 5 years, the coal fleet has maintained an average on-site stockpile of 73 days of sub-bituminous coals and 82 days of bituminous coal.

Several recent reports, including those by the National Academy of Sciences and PJM, cite the importance of the coal fleet's on-site fuel supply that contributes to grid reliability and resilience.

Despite its contribution to reliability and resilience, the coal fleet faces a number of challenges. These include environmental expenditures, low natural gas prices, mandates and incentives for renewables, out-of-market subsidies and market rules that do not properly value the attributes of the coal fleet.

Market rules are important because almost two-thirds of the coal fleet serves also electricity markets. Last week, DOE took an important step by proposing a rule that directs FERC to adopt certain electricity market reforms.

The rule would require RTOs and ISOs to adopt market rules to ensure that fuel security, reliability, and resilience attributes such as those provided by the coal fleet are fully valued.

Although we are still evaluating the proposal, it represents a major step towards achieving at least some reforms in wholesale electricity markets.

However, to achieve DOE's goal and prevent more premature coal retirements, these reforms must be adopted quickly. FERC must provide strong leadership and act expeditiously and grid operators must adopt these and other reforms as soon as possible.

Thank you again for the opportunity to testify today.

[The prepared statement of Mr. Bailey follows:]

Testimony of Paul Bailey

President and Chief Executive Officer

American Coalition for Clean Coal Electricity

Before the House Committee on Energy and Commerce

Subcommittee on Energy

At the hearing entitled:

"Part II: Powering America: Defining Reliability in a Transforming Electricity Industry"

October 3, 2017

Highlights of ACCCE Testimony

- The electric sector is undergoing changes that could affect the reliability and resilience of the electric grid. These changes include the retirement of a large amount of traditional baseload generating capacity, in particular coal-fueled generating capacity.
- Currently, the nation's coal fleet is comprised of 1,004 individual generating units located at 377 power plants that represent a total of 262,000 megawatts (MW) of electric generating capacity. Some 60,000 MW of coal-fueled generating capacity (20 percent of the coal fleet) had retired by the end of last year. An additional 41,000 MW have announced plans to retire. Altogether, these retirements represent one-third of the nation's coal fleet.
- The coal fleet provides many attributes that help ensure the reliability and resilience of the electric grid. These attributes include on-site fuel supplies that have averaged 73 to 82 days. Without fuel security, the electric grid is less reliable and less resilient.
- Almost two-thirds of the coal fleet (174,000 MW) serves wholesale electricity markets. However, the contributions of the coal fleet to grid reliability and resilience are not being properly valued in these wholesale markets. This is contributing to coal retirements.
- Recently, DOE has proposed a rule aimed at preventing further premature retirements of baseload electric generating capacity. The proposed rule directs FERC to require grid operators to adopt market reforms to value the onsite fuel and other reliability attributes provided by the coal fleet. This action by DOE is a major step toward achieving long overdue wholesale electricity market reforms.

Testimony of Paul Bailey
President and Chief Executive Officer
American Coalition for Clean Coal Electricity

Before the Committee on Energy and Commerce
Subcommittee on Energy
United States House of Representatives
Hearing entitled: "Part II: Powering America: Defining Reliability in a Transforming Electricity Industry"

October 3, 2017

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee, my name is Paul Bailey. I am President and Chief Executive Officer of the American Coalition for Clean Coal Electricity (ACCCE). We commend the subcommittee for holding this hearing and appreciate the opportunity to testify today regarding changes to the nation's electric grid and the contribution of the coal fleet to grid reliability and resilience.

The mission of ACCCE is to advocate on behalf of the nation's fleet of coal-fueled power plants. Our members include electricity generators, coal producers, railroads, barge lines, and equipment manufacturers. Their operations, in one way or another, involve the production of electricity from coal.

Here are a few facts about the coal fleet:

- Currently, the coal fleet is comprised of 1,004 individual generating units located at 377 power plants and representing a total of 262,000 megawatts (MW) of electric generating capacity.[i]
- Some 60,000 MW of coal-fueled generating capacity had retired by the end of last year. An additional 41,000 MW have announced plans to retire. In

total, 43 states have coal-fueled generating units that have either retired or have announced plans to retire.[ii]

- The coal fleet helps to provide affordable and reliable electricity to consumers in 48 states. Moreover, the fleet provides at least half the electricity in 13 states and at least one quarter of the electricity in 26 states.[iii]
- According to EIA, the coal fleet was responsible for slightly more than 30 percent of electricity generated in the U.S. last year and is projected to supply 31 percent of U.S. electricity this year and next year.[iv] Through 2030, EIA projects that coal will provide 31 percent of U.S. electricity needs.[v]

A reliable and resilient electric grid is essential for public health, public safety, a sound economy, and national security. It is obvious the nation's electric grid is undergoing profound changes that could challenge grid reliability and resilience. Your invitation asked each member of the panel to address two questions that are relevant to these changes. The first, in my case, is how does the coal fleet contribute to reliability and what are its unique attributes? The second is what challenges does the coal fleet face? Our responses follow.

"How does the coal fleet contribute to reliability and what are its unique attributes?" The North American Electric Reliability Corporation (NERC) is charged with ensuring the reliability of the nation's bulk power supply system (power plants and the high voltage transmission system). NERC defines reliability as ensuring resource adequacy — that is, maintaining generation reserves such that load shedding due to inadequate supply would occur only once in ten years, or "loss of load expectation" — plus ensuring the bulk power system can withstand sudden disturbances and avoid uncontrolled cascading outages.[vi] In other words, reliability means having sufficient supplies of electricity along with a transmission system that will keep the lights on, even in the face of short-term disturbances.

The U.S. bulk power system is considered to be extremely reliable.[vii] However, as the subcommittee noted, changes in the electricity generation mix make this a critical time to carefully examine reliability, as well as resilience. Several groups have identified attributes that various electricity resources — coal, gas, nuclear, renewables, demand response, and storage — contribute to reliability. These reliability attributes are listed below in no particular order. (Note that there may be attributes that others might include in the list.)

- Dispatchability,
- Frequency response / inertia,
- Voltage control / reactive power,
- Contingency reserves / spinning reserves,
- Ramp capability,
- Regulation,
- Load following,
- Minimum load,
- Black start capability,
- Fuel security / on-site fuel,
- Resource availability (non-intermittency),
- Equivalent availability factor,
- Flexibility (cycling and short startup times),
- Vulnerability to single points of disruption,
- Storage capability, and
- Price stability.[viii]

The coal fleet provides most of these attributes, especially fuel security (or assurance). Without fuel security, the electric grid is less reliable and less resilient. At the same time, it is important to recognize that no single resource provides each and every reliability attribute. This is why fuel diversity is critical to reliability and why the retirement of a large number of coal-fueled generating units is concerning.

While reliability is critical, NERC, DOE, and others (including Congress) have begun to focus more attention on grid resilience. For example, Congress called for an independent assessment of the reliability and resilience of the electric grid in 2014. This assessment, "Enhancing the Resilience of the Nation's Electricity System," was released by the National Academies of Science, Engineering, and Medicine (NAS) two months ago. The NAS report notes that grid resilience is "not just about being able to lessen the likelihood that outages will occur, but also managing and coping with outage events as they occur to lessen their impacts, regrouping quickly and efficiently once an event ends, and learning to better deal with other events in the future."[ix] Similarly, PJM explains that resilience "relates to preparing for, operating through, and recovering from a high-impact, low frequency event. Resilience is remaining reliable even during these events."[x]

The importance of resilience is highlighted elsewhere. For example, in June, NERC testified that "[S]ystem resiliency is becoming an enhanced yardstick of reliability."[xi] PJM's "Evolving Resource Mix" released earlier this year includes analysis in which the PJM electric resource portfolio is subjected to an assumed Polar Vortex event (see below).[xii] Also, the DOE report reviews extreme weather events that have tested the grid's resilience and notes that "more work is needed to define, quantify, and value resilience."[xiii]

Both the DOE and NAS reports refer to the coal fleet's onsite fuel attribute that contributes to grid resilience. According to DOE, "Fuel assurance is a growing consideration for the electricity system. Maintaining onsite fuel resources is one way to improve fuel assurance ... Coal facilities typically store enough fuel onsite to last 30 days or more."[xiv] The NAS report recommends that "fuel diversity, dual fuel capability, and local storage should explicitly be addressed as a part of these resilience strategies."[xv]

PJM's "Evolving Resource Mix" analyzes an assumed Polar Vortex scenario to test the resilience of its electricity resource mix. The analysis evaluates 98 "desirable" resource portfolios (different amounts of coal, gas, nuclear, and demand response) and finds that only one-third of the portfolios were resilient against Polar Vortex conditions. PJM observed that "the majority of the resilient portfolios in this polar vortex sensitivity preserve a high share of coal."[xvi] Most of the resilient portfolios included the same amount of coal-fueled capacity that PJM has in its current resource mix.

Similar findings are also highlighted in a recent study for ACCCE by PA Consulting Group.[xvii] PA concludes that coal-fueled generation provides attributes that are critical for maintaining grid reliability and resilience. In particular, PA notes that "two components that contribute to electric system resilience are (i) diversification of the fuels used, and (ii) ensuring adequate and consistent fuel supply to electric generators." PA goes on to note that "coal-fueled plants ... have unique attributes that contribute to grid resilience, including a secure fuel supply."

The secure fuel supplies at coal-fueled power plants serve as an insurance policy against fuel disruptions that can occur with other fuels. In contrast to coal-fueled power plants, natural gas-fueled plants rely on deliveries via pipeline, leaving them vulnerable to supply disruptions, especially when high-impact, low-probability events occur. For example, at least 30 percent of the natural gas delivered to power plants in the Northeast and Mid-Atlantic states is subject to curtailment, under which pipelines and local distribution companies can cut off gas supplies in the event of needs by residential and commercial heating customers.[xviii] The coal fleet can continue generating electricity for weeks even if coal deliveries are interrupted because the average coal-fueled power plant maintains more than a two-month supply (73 to 82 days) of coal onsite.[xix]

"What challenges does the coal fleet face?" Despite its contribution to fuel diversity, reliability, resilience, and affordable electricity prices, the coal fleet has faced and still faces a number of challenges. These include massive environmental compliance expenditures over the past six years; uncertainty over future environmental policies; low natural gas prices; mandates and tax incentives for renewables; out-of-market subsidies for other resources; and wholesale electricity market rules that do not properly value the reliability and resilience attributes of the coal fleet.

The latter challenge is especially important because almost two-thirds of the coal fleet (174,000 MW) serves wholesale electricity markets whose price formation policies are badly in need of reform. We believe the competitive markets do not adequately value all essential reliability and resilience attributes of the coal fleet. However, the markets can be structured to price these attributes, and FERC has a vital role in helping to accomplish this.

While three-fourths of coal retirements have been attributed, at least in part, to EPA regulations, many recent retirements have been directly linked to wholesale market conditions.[xx] For example, Dynegy attributed the retirement of its Wood River plant and the shutdown of units at its Baldwin and Newton plants in Illinois in 2016 and 2017 to the "poorly designed wholesale capacity market."[xxi] Similarly, the retirement of plants in Ohio has been blamed on market conditions, including the planned retirement of four units at First

Energy's Sammis plant in 2020, as well as Dayton Power and Light's announcement that it is retiring the Killen and Stuart plants in 2018.[xxii] Some 8,000 MW of coal-fueled generating capacity in PJM, MISO, and NYISO that have retired or are expected to retire between 2016 and 2020 have been attributed to wholesale market conditions.[xxiii]

In addition to market conditions, federal tax incentives for renewable energy have encouraged renewable energy development and deployment. According to DOE, "the ... ITC and PTC, as well as state-level RPS, have driven expansion of VRE, particularly wind and solar ... These policies reduce revenues for traditional baseload power plants by lowering the wholesale electric prices they receive and by displacing a portion of their output."[xxiv]

With the retirement of coal and nuclear units, EIA projects that natural gas and renewables will comprise almost 75 percent of the nation's electric generating capacity by 2040.[xxv]

Path Forward DOE notes in its report that evolving market conditions show that "markets need ... reform to address future services essential to grid reliability and resilience."[xxvi] DOE recommends that FERC "create ... regulatory mechanisms that compensate grid participants for services that are necessary to support reliable grid operations." With respect to resilience, DOE recommends that "RTOs and ISOs should further define criteria for resilience, identify how to include resilience in business practices, and examine resilience-related impacts of their resource mix."[xxvii] ACCCE supports these recommendations.

Just recently, DOE proposed a rule directing FERC to adopt electricity market reforms to prevent the premature retirement of baseload power plants. This rule would require RTOs and ISOs to adopt market rules to ensure that fuel security, reliability, and resilience attributes are fully valued. DOE's proposal is a major step toward achieving long overdue reforms in wholesale electricity markets. However, to achieve DOE's goal, these reforms must be adopted as quickly as possible. FERC must provide strong leadership and act expeditiously, and grid operators must adopt reforms as quickly as possible.

Thank you for the opportunity to testify today. I look forward to answering your questions.

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[i] SNL Energy data; EIA Electric Power Monthly, August 2017.
[ii] ACCCE, *Retirement of Coal-Fired Electric Generating Units as of June 17, 2017*.
[iii] EIA, Electric Power Monthly, February 2017.
[iv] EIA, Short Term Energy Outlook, August 2017.
[v] EIA, Annual Energy Outlook 2017, January 5, 2017.
[vi] North American Electric Reliability Corporation, "Frequently Asked Questions," August 2013.
[vii] See, for example, North American Electric Reliability Council (NERC), *State of Reliability 2017* (June 2017).
[viii] PJM Interconnection, *PJM's Evolving Resource Mix and System Reliability*, March 30, 2017; Hubbard, P., S. Tierney, and K. Franklin, *Electricity Markets, Reliability and the Evolving U.S. Power System*, Analysis Group, June 2017; Lannoye, E., E. Ela, and D. Brooks, "Grid Impacts and Challenges Arising from the Integration of Inverter-Based Variable Resources," EPRI, ISO New England Stakeholder Meeting, October 19, 2016; Shavel, I, M. Kline, R. Lueken, and P. Ruiz, *Diversity of Reliability Attributes: A Key Component of the Modern Grid*, Prepared for the American Petroleum Institute, May 17, 2017; PA Consulting Group, Inc., *The Contribution of the Coal Fleet to America's Electricity Grid*, Prepared for the American Coalition for Clean Coal Electricity, August 2017.
[ix] National Academies of Sciences, Engineering, and Medicine. 2017. *Enhancing the Resilience of the Nation's Electricity Systems.* Washington, DC: The National Academies Press. https://doi.org/10.17226/24836. ("NAS Report")
[x] PJM Interconnection, *PJM's Evolving Resource Mix and System Reliability*, March 30, 2017, footnote 16.
[xi] Remarks of Mark Lauby, Senior Vice President and Chief Reliability Officer, North American Electric Reliability Corporation, FERC Reliability Technical Conference, Panel III: The Potential for Long-term and Large-Scale Disruptions to the Bulk-Power System, June 22, 2017.
[xii] PJM Interconnection, Appendix to PJM's *Evolving Resource Mix and System Reliability*, March 30, 2017, at 40-41.

[xiii] DOE, *Staff Report to the Secretary on Electricity Markets and Reliability*, August 2017 ("DOE Report") at 100.
[xiv] DOE Report at 11. The DOE report does mention frozen coal piles as occurring during extreme cold, but while this did occur during the 2014 Polar Vortex, NERC's review of that incident shows that natural gas represented over 55% of outages during the event, to coal's 26%. (NERC, *Polar Vortex Review*, September 2014)
[xv] NAS Report at 4-22.
[xvi] PJM Interconnection, Appendix to PJM's *Evolving Resource Mix and System Reliability*, March 30, 2017.
[xvii] PA Consulting Group, Inc., *The Contribution of the Coal Fleet to America's Electricity Grid*, Prepared for the American Coalition for Clean Coal Electricity, August 2017.
[xviii] *Ibid*.
[xix] EIA, *Electricity Monthly Update*, accessed July 27, 2017. This is the average amount of coal stockpiled over the past five years. Plants that use bituminous coal have an average stockpile equivalent to 82 days; plants burning subbituminous coal average 73 days.
[xx] ACCCE, *Retirement of Coal-Fired Electric Generating Units as of June 17, 2017*.
[xxi] Bandyk, Matthew, "Dynegy to shut more Illinois coal plants, calls for fixes in MISO market, *SNL Energy*, May 3, 2016; Bandyk, Matthew, "Dynegy to retire Illinois coal plant due to 'flawed' MISO auction," *SNL Energy*, November 4, 2015.
[xxii] Qureshi, Nazia, "First Energy to abandon 856 MW of Ohio coal units, record $647M Q2 impairment," *SNL Energy*, July 22, 2016; Sweeney, Darren, "DP&L commits to retiring nearly 3,000 MW of Ohio coal capacity in 2018," SNL Energy, March 20, 2017.
[xxiii] ACCCE, *Retirement of Coal-Fired Electric Generating Units as of June 17, 2017* and backup data.
[xxiv] DOE Report at 49-50.
[xxv] EIA, Annual Energy Outlook 2017.
[xxvi] DOE Report at 10.
[xxvii] *Ibid* at 126.

Mr. UPTON. Thank you.

Next, we are joined by Ms. Maria Korsnick, president and CEO of NEI. Welcome.

STATEMENT OF MARIA G. KORSNICK

Ms. KORSNICK. Thank you very much.

For many decades, the Americas' fleet of nuclear reactors have served this Nation by providing clean base load power and support for local infrastructure.

Today, those same plants, which support over 475,000 jobs across America, are being threatened by energy markets which do not value nuclear's attributes.

This practical and public policy issue must no longer be ignored. I thank Chairman Upton and Ranking Member Rush for holding this hearing. We need an open and honest conversation about what should be done to maintain these important assets.

Last week the U.S. Department of Energy, under the leadership of Secretary Perry, issued a directive ordering FERC to take swift action to address U.S. electrical grid resiliency.

This action is a result of DOE's recent report highlighting the impact that market and regulatory policies are having on base load power plants including our Nation's nuclear reactors.

Additionally, the IHS Markit issued a report valuing diversity at $114 billion a year. It's essential this committee encourages FERC and the RTOs to work together to create the market rules for the diverse portfolio that we need.

Unfortunately, current market designs fail to compensate the unique and beneficial attributes of nuclear generation and here is what I mean.

First, nuclear produces reliable base load power while not emitting harmful air pollutants or carbon dioxide. It produces large quantities of electricity around the clock safely and reliably, operating over 90 percent of the time for the past 15 years. That's higher than any other generation source.

And we provide ancillary services such as voltage, frequency, and reactive power support to the grid. Our reactors are secure hardened facilities which have the fuel to run for 18 to 24 months, avoiding reliance on just-in-time fuel delivery.

This is essential when natural disasters and catastrophic events occur and we help create the fuel and technology diversity that is a bedrock characteristic of a reliable, resilient electric sector which helps create affordable and stable rates for consumers.

Let's talk about some real examples. During the 2014 polar vortex, nuclear generators performed than all other forms of generation, operating with an average capacity factor of 95 percent.

More recently, despite Hurricane Harvey's devastating impact on the region, the two south Texas nuclear plants continued operating at 100 percent power during the storm, providing much-needed electricity to police stations, hospitals, and shelters.

And Hurricane Irma ravaged Florida, the St. Lucie Nuclear Plant on Florida's east coast, operated a reactor at 100 percent power to provide what remained of the grid much-needed power for critical services.

The DOE study did a good job laying out the challenges facing the electricity system and among these are unprecedentedly low natural gas prices, low electricity demand growth, and increased use of variable renewable energy due to regulation and mandates at the State and Federal levels, which are creating unintended consequences for all electricity generators but particularly base load plants.

Although DOE found that the markets have met short-term reliability needs at low cost, DOE determined that FERC must reform the markets to address system resilience and long-term grid stability.

Comprehensive reform must resolve two pressing problems. The markets are not functioning well when prices are negative. Reactors are, in fact, forced to pay grid operators to take their power.

And second, market designs fail to compensate nuclear generation with a unique set of attributes that I've discussed. These attributes play an important role in creating affordable electricity for our consumers.

As we've awaited Federal action, State solutions have preserved seven reactors and saved thousands of jobs in New York and Illinois and are helping bridge us towards a secure energy future.

I cannot overstate the need for FERC and the RTOs to expeditiously implement solutions. Since 2013, three nuclear reactors have prematurely retired due to market conditions and another eight reactors are scheduled to prematurely retire for market or policy reasons.

Now, some of these plants will shut down more than a decade before their operating licenses expire, and when a nuclear plant shuts down, the Nation irrevocably loses a reliable source of continuous generation and electricity prices and air emissions both increase.

I did not paint a rosy picture today but I painted an accurate one. America's nuclear fleet and all the value it brings to our Nation is in clear and present danger without your action.

As China and Russia aggressively attempt to replace our Nation as the world's leader in nuclear technology, it's now more imperative than ever that this committee take action.

I applaud your leadership in holding this series of hearings and I look forward to working together to find ways to fix the current market flaws and to ensure America's nuclear fleet not only survives but thrives as part of our Nation's diverse and reliable system.

Thank you.

[The prepared statement of Ms. Korsnick follows:]

Testimony for the Record
Maria G. Korsnick
President and Chief Executive Officer
Nuclear Energy Institute
Before the
Subcommittee on Energy, House Energy and Commerce Committee
October 3, 2017

I am Maria Korsnick, President and Chief Executive Officer of the Nuclear Energy Institute (NEI).[1] NEI appreciates the opportunity to provide testimony on the challenges facing our electricity system and what they mean for ensuring the system is reliable, resilient, and affordable in the long term.

The recent U.S. Department of Energy (DOE) report on electricity reliability described the adverse impact that market and regulatory policies are having on baseload power plants.[2] We commend DOE for its balanced analysis of the causes of baseload plant closures and urge federal policymakers to act on the report's recommendations.

A resilient and diverse portfolio of fuels and technologies—nuclear, coal, natural gas, hydro, wind, solar—is the core strength of our electric system. As recommended by DOE, the Federal Energy Regulatory Commission (FERC) should swiftly act to ensure each electricity generators' contribution to reliability and resilience is fully recognized in market prices. FERC has been considering these issues for years but significant problems persist. Comprehensive market reform is overdue. I urge members to encourage FERC to move on these issues. Action by FERC will benefit all Americans by helping to retain nuclear's contribution to reliability, system resilience, energy security and diversity, price stability, and clean air.

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[1] NEI is responsible for establishing unified industry policy on issues affecting the commercial nuclear energy industry. NEI has more than 300 members, including all the companies licensed to operate commercial nuclear power plants in the United States, as well as nuclear plant designers, major architectural and engineering firms, entities that process nuclear fuel, and other organizations involved in the nuclear industry.

[2] DOE, *Staff Report to the Secretary on Electricity Markets and Reliability* (Aug. 2017).

Nuclear generation provides unmatched reliability while promoting clean air and national security.

Nuclear energy is the largest source of emissions-free electricity in the United States. Currently, 99 reactors in 30 states produce nearly 20 percent of our nation's electricity and approximately 60 percent of our carbon-free electricity. Nuclear produces electricity 24/7 and has the added benefit of having all its fuel on site for 18-to-24 months. The long horizon for nuclear fuel procurements also means nuclear generation is not subject to price spikes occasionally experienced by other generation sources in recent years.

Because nuclear facilities have onsite fuel and hardened facilities, they typically operate continuously in extreme weather conditions. During the Polar Vortex nuclear generators performed better than all other forms of generation—operating with an average capacity factor of 95 percent.[3] And despite Hurricane Harvey's devastating impact on the region, the two South Texas Project units in Matagorda County continued operating at 100 percent power during the storm, providing much needed electricity to those customers whose power lines remained intact. To be sure, operators do take nuclear plants offline for refueling and other reasons as dictated by the circumstances, but overall nuclear energy facilities have proven their unmatched reliability by operating with an average capacity factor greater than 90 percent over the last 15 years.

In addition, a robust commercial nuclear energy industry is vital for U.S. national security interests. It is important that we not allow nuclear plant closures to cede our nation's role as the world leader on nuclear energy. This is particularly important given that Russian and Chinese state-owned nuclear enterprises are aggressively moving to export their technologies to countries entering the global nuclear marketplace, such as Turkey and Pakistan.[4] Exporting U.S. nuclear

[3] DOE, *Staff Report to the Secretary on Electricity Markets and Reliability* at 95.

[4] *See* Mark Hibbs, Senior Fellow, Carnegie Endowment for International Peace, *Does the U.S. Nuclear Industry Have a Future?* (Aug. 10, 2017).

technologies means establishing a 100-year relationship with those countries as U.S. companies help to site, build, operate, service, and decommission those reactors. Nuclear exports also help embed our nation's high standards for safety, security, and nonproliferation worldwide. As recent reports have concluded, a viable domestic commercial nuclear industry is imperative to our energy security, balance of trade, and national security.[5]

Wholesale market structural defects undermine reliability, system resilience, and our national security.

The DOE study did a good job laying out the challenges facing the electricity system. Among these are unprecedentedly low natural gas prices, low electricity demand growth, and increased use of variable renewable (solar and wind) energy due to various regulations and mandates at the state and federal levels, which are creating unintended consequences for all electricity generators but particularly baseload plants. Although DOE found that independent system operator and regional transmission organization (RTO) markets have met short-term reliability needs at low cost, DOE determined that FERC—which regulates the RTOs—must reform the RTO markets to address system resilience and long-term grid reliability.

Comprehensive reform must resolve two pressing problems. First, market rules cause defects in what is known as "price formation"—essentially the rules that govern how market prices are set. For example, to ensure nuclear generation is available when needed during peak hours, RTOs rely on nuclear facilities—which cannot easily shut down and then restart—to run overnight, during periods of low demand when variable resources are flooding the market with power. Even though the RTOs rely on nuclear generation to meet reliability needs, RTO rules force nuclear facilities to be "price-takers," meaning nuclear facilities cannot set market prices. Instead,

[5] Energy Futures Initiative, *The U.S. Nuclear Energy Enterprise: A Key National Security Enabler* (Aug. 2017); Jeremy Carl & David Fedor, Hoover Institute, *Keeping the Lights on at America's Nuclear Power Plants* (2017).

variable resources or resources that can ramp-up quickly set market prices. As a result, nuclear facilities receive market prices that at times are below their true costs and even *negative*, which essentially causes nuclear generators to have to pay the RTOs to take their power. These RTO rules result in energy prices that, at least during some hours, do not reflect the true economic cost of resources actually providing power to the grid.

Second, RTO market designs fail to compensate nuclear generation for the unique set of valuable attributes it provides. This includes: (1) producing no criteria pollutants or carbon dioxide; (2) producing large quantities of electricity around the clock, safely, and reliably; (3) operating regardless of most weather conditions; (4) avoiding reliance on "just-in-time" fuel deliveries by having 18-to-24 months of fuel onsite; (5) providing price stability with respect to low marginal cost production; and (6) contributing to the fuel and technology diversity that is a bedrock characteristic of a reliable, resilient electric sector. These attributes play an important role in creating affordability for electricity customers. For example, customers benefit greatly from energy diversity because it serves as a hedge against unanticipated future market conditions. Significantly, the diversity of energy portfolio lowers U.S. customers' power bills by over $93 billion per year.[6]

FERC should expedite efforts to improve price formation and recognize nuclear generation's undervalued attributes.

NEI cannot overstate the need for FERC and the RTOs to expeditiously implement solutions to address these issues. Since 2013, three nuclear plants have prematurely retired due to market conditions and another six plants are scheduled to prematurely retire for market or policy reasons. Some of these plants will shut down more than a decade before their operating licenses expire. When a nuclear plant shuts down, the nation irrevocably loses a reliable source of continuous generation. We also lose the stability of energy diversity and the many other societal

[6] *See* IHS Markit, *The Value of US Power Supply Diversity* (July 2014).

benefits provided by nuclear power, including thousands of jobs. And when a nuclear plant shuts down, both air emissions[7] and electricity prices increase.[8]

FERC and the RTOs should undertake comprehensive efforts to: (1) improve price formation to ensure wholesale prices reflect the true economic marginal cost of the resources supplying electricity; and (2) provide compensation for undervalued benefits such as contributions to system resilience, long-term price stability, fuel diversity, and the environment.

FERC has been considering price formation issues for several years yet problems persist. Reforms that are more comprehensive should not be controversial: price formation improvements will allow the market to better reflect the actual cost of generating the electricity we need. Improving price formation to provide fair compensation would be good for all forms of generation. Although PJM for example is considering promising price reform efforts to recognize the reliability contributions of both baseload and flexible resources in price formation,[9] these efforts are likely to stay on a shelf unless FERC pushes the RTOs move forward. FERC has the tools and authority to initiate such action. FERC needs to act.

Beyond these price formation efforts, comprehensive long-term reforms are needed to ensure a coherent national policy framework that values the attributes important to our electricity system such as system resilience, onsite fuel security, fuel and technology diversity, long-term price stability, clean air, and public health. FERC should push the RTOs to develop market structures to value these traditionally overlooked, yet much needed, attributes.

Although FERC must urgently act to improve the wholesale market structure, FERC

[7] The loss of Vermont Yankee alone increased carbon emissions in New England by five percent. ISO New England, *2015 ISO New England Electric Generator Air Emissions Report* (Jan. 2017).

[8] California electricity customers paid $350 million more for electricity in the year following San Onofre's closure. Lucas Davis & Catherine Hausman, Energy Institute at Haas, University of California at Berkeley, *Market Impacts of a Nuclear Power Plant Closure* (May 2015).

[9] PJM Interconnection, *Energy Price Formation and Valuing Flexibility* (June 15, 2017).

should not limit legitimate state policy goals. The Federal Power Act expressly leaves decisions about generation (including the mix of resources) to states. States likewise retain broad powers over environmental regulation. When states operate within areas of state authority, FERC cannot take action to limit these authorities. Thus, it would be inappropriate for FERC to interfere with state-based nuclear programs that provide compensation for legitimate state interests, such as environmental benefits, that are not tied to wholesale energy or capacity sales.

Conclusion

On behalf of NEI and its members, I wish to thank the subcommittee for holding this hearing and encourage members to weigh in with FERC on these important issues. FERC has the authority to take these actions, and with additional direction from Congress, FERC can be expected to act in a timely and appropriate manner. The series of hearings on the Federal Power Act can also play a critical role shaping future legislation to address market flaws.

Mr. UPTON. Thank you.

Next, we are joined by Mr. Tom Kiernan, CEO of American Wind Energy Association.

Tom, welcome back.

STATEMENT OF THOMAS C. KIERNAN

Mr. KIERNAN. Thank you very much.

Chairman Upton, Ranking Member Rush, and other distinguished members of the subcommittee, thank you very much for the opportunity to testify on behalf of the diverse membership of the American Wind Energy Association.

AWEA represents the entire supply chain of the wind industry, from family-owned construction companies in Minneapolis, to some of the country's largest utilities, to Fortune 500 companies that are increasingly buying our product, wind energy.

The wind industry welcomes the focus on reliability and resilience and we have consistently supported more rigorous reliability standards at FERC and NERC.

Now, this should not be surprising, given our advanced technology, that some of you may not be aware of, now enable wind to provide many if not most of the essential reliability services needed for the grid.

As NERC has noted, reliability and resilience of the grid are good and increasing and that wind energy contributes to providing these reliability services and resilience of the grid.

Wind is not only capable of delivering these services but also has demonstrated a strong track record of doing so and I'd like to share six brief examples, if I may.

First, during the 2014 polar vortex, wind energy was resilience to cold weather and helped keep the lights on while 13,000 megawatts of coal and 1,400 megawatts of nuclear were forced offline in PJM alone despite having onsite fuel.

Second, and similarly, during the 2011 Texas cold snap, wind energy received accolades from the grid operators while over 3,000 megawatts of coal went offline, despite onsite fuel.

Third, and more recently, most wind plants along the Texas coast continued producing energy as Hurricane Harvey came ashore and were producing as long as the grid was up.

In contrast, two coal units were forced offline and stayed offline due to flooded onsite fuel.

Fourth, grid operators in Texas and Colorado now regularly dispatch the output of wind plants up and down to provide frequency response and balance electricity's supply and demand with a degree of speed and accuracy that exceeds most conventional power plants.

Fifth, during several summer droughts coal and nuclear plants have been curtailed due to inadequate cooling water, again, despite having onsite fuel.

And lastly, Iowa and Kansas now produce more than 30 percent of their electricity from wind, South Dakota and Oklahoma more than 25 percent, and this last year down in Texas, the main operator produced over 15 percent of their electricity from wind, and reliability is at an all-time high, with wind providing some of the essential reliability services such as reactive power and frequency response.

I would now like to offer four recommendations for electricity policy makers. In summary, first, rely on competitive markets; second, focus on reliability services, not generation sources; third, do not be distracted by perceived problems; and fourth, promote transmission infrastructure. I will go quickly through each.

First, rely on competitive markets—competitive markets enable a cost-effective division of labor among energy sources. Each energy source will deliver the reliability services it can provide best and at the lowest cost, resulting in a cost-effective delivery of a stable grid.

Secondly, focus on reliability services, not generation sources. Grid operators should seek to identify and compensate for reliability services and not some fuel characteristics such as whether a resource as onsite fuel.

In other words, focus on the services that the power system needs like flexibility, disturbance ride-through capability, frequency in voltage support, and actual energy production in times of high demand and not the fuel type of the generator.

FERC RTOs and NERC are well equipped to define the services needed.

Third, do not be distracted by perceived problems. I've seen frequent mention of the supposed harmful effects of negative pricing.

As the DOE notes in their recently released grid study, negative crisis "have had almost no impact on annual average day-ahead or real-time wholesale electricity prices," and are also often caused by fossil or nuclear power plants.

And fourth, promote transmission infrastructure development. Building a more robust transmission system is the single most effective tool for improving resiliency.

A strong integrated power grid would provide the same vast benefits as our interstate highway system has in allowing the most competitive businesses to deliver their low-cost products to consumers.

So, in sum, we support the objectives of maintaining reliability and resilience and urge that they be promoted through free and open markets with a focus on reliability services, not generation sources, and a program to promote transmission infrastructure development.

Thank you very much.

[The prepared statement of Mr. Kiernan follows:]

Testimony of Thomas C. Kiernan, CEO

American Wind Energy Association

Before the U.S. House of Representatives Energy and Commerce Committee Subcommittee on Energy

Hearing entitled "Defining Reliability in a Transforming Electricity Industry"

October 3, 2017

Chairman Upton, Ranking Member Rush, and other distinguished members of the Subcommittee, thank you for the opportunity to testify on behalf of the diverse membership of the American Wind Energy Association. The wind industry welcomes the focus on electric reliability and resilience, as modern wind energy facilities strongly support these objectives. Thanks to technological advances driven in part by the ingenuity of America's more than 100,000 wind industry employees, wind plants can now provide the grid reliability services traditionally provided by conventional power plants.

As NERC has noted, wind energy "offers ride-through capabilities and other essential reliability services."[1] Advanced power electronics and fast controls allow wind plants to regulate power system frequency and voltage, and ride through grid disturbances. Wind's resilience was demonstrated during the 2014 Polar Vortex event and a similar cold snap in Texas in 2011, when high wind output helped keep the lights on while many coal, nuclear and natural gas plants went offline.

[1] NERC, "2014 Long-Term Reliability Assessment," page 15, available at http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2014LTRA_ERATTA.pdf

Of course, no energy source cost-effectively provides all grid reliability services at all times, which is why markets are critical. Markets enable a division of labor among energy sources, with each delivering the services it can provide best at that point in time.

I offer four key recommendations regarding policy to promote electric reliability and resilience:

1) Rely on competitive markets: Wholesale electricity markets have performed well at providing affordable and reliable electricity. The RTOs, FERC, and NERC should continue to competitively procure services through markets without putting their thumbs on the scale for any generation source or technology.
2) Focus on reliability needs, not generation sources: Identify and compensate for the reliability services that are needed, not the fuel type of the generator or other resource characteristics that are not reliability services (e.g. having onsite fuel, being physically close to load).
3) Do not be distracted by perceived problems: As last month's DOE report notes,[2] negative prices "have had almost no impact on annual average day-ahead or real-time wholesale electricity prices," are often caused by fossil or nuclear power plants, and typically occur in remote parts of the grid where they have little to no impact on other power plants. As then-FERC Commissioner John Norris concluded after looking into the matter, focusing on negative prices is a "distraction," while "transmission development is the better, and more proactive, solution."[3]
4) Promote transmission infrastructure development: Building a more robust transmission system is the single most effective tool for improving resiliency and providing customers greater access to low-cost sources of energy, whether nuclear, renewable, or fossil.

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[2] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[3] FERC, "Commissioner John R. Norris Statement," May 2014, available at https://ferc.gov/media/statements-speeches/norris/2014/05-15-14-norris.asp

Wind contributes to electric reliability and resilience

Technological advances have reduced the cost of wind energy by two-thirds over the last 8 years, and have also enabled wind to compete in markets for grid reliability services. A 2016 Department of Energy report confirms that wind and solar plants contribute to the essential reliability services the grid needs.[4] The following table[5] documents how wind plants contribute to grid reliability services and resilience.

Reliability Service	Wind	Solar PV	Gas	Coal	Nuclear
Disturbance ride-through					
Note: For the following reliability services, yellow means the resource can provide the service but during many hours it may not be the most economic choice to do so.					
Reactive and voltage control					
Frequency regulation					
Flexibility					
Primary frequency response and inertial response to disturbances					
Resilience Service	Wind	Solar PV	Gas	Coal	Nuclear
Note: For the following resilience services, score reflects risk of common mode unavailability reducing fleetwide output below capacity value during challenging time period.					
Cold weather resilience					
Hot weather resilience					
Fuel delivery resilience					
Cooling water resilience					
Impact on System Variability	Wind	Solar PV	Gas	Coal	Nuclear
Impact on operating reserves and flexibility needs of other generators					
Key: **Green** is positive, yellow is medium value, **red** indicates that in most cases the resource does not offer that service.					

[4]DOE, "Maintaining Reliability in the Modern Power System," December 2016, available at https://www.energy.gov/sites/prod/files/2017/01/f34/Maintaining%20Reliability%20in%20the%20Modern%20Power%20System.pdf

[5]For larger table with linked citations:http://awea.files.cms-plus.com/FileDownloads/pdfs/Services%20Graphic.pdf

Recognizing that all mainstream energy sources must be good stewards of electricity reliability, the wind industry has consistently supported more rigorous reliability standards at FERC and NERC. Wind plants participate fully in electricity markets and abide by the same rules as other power plants.

Wind is not only capable of delivering reliability and resilience, but its track record is demonstrated. As NERC's CEO testified here last month, "Variable resources significantly diversify the generation portfolio and can contribute to reliability and resilience in important ways." Iowa and Kansas now produce more than 30% of their electricity from wind, with South Dakota and Oklahoma over 25%. The main Texas power system obtained 15% of its electricity from wind last year, and Colorado's main utility and the Southwest Power Pool are approaching 20%.

Electric reliability has greatly improved as wind has been added in Texas,[6] and NERC recently noted that power system frequency response is noticeably higher when wind output is high in the state.[7] Grid operators in Texas and Colorado now regularly dispatch the output of wind plants up and down to balance electricity supply and demand, with a degree of speed and accuracy not available from conventional power plants.

In addition to wind's resilience during the cold snap events in 2014 and 2011,[8] wind energy fared well during recent hurricanes. Most wind plants along the Texas coast continued producing at nearly full

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[6]ERCOT, "ERCOT Monthly Operational Overview," July 2017, page 6, available at http://www.ercot.com/content/wcm/key_documents_lists/27311/ERCOT_Monthly_Operational_Overview_201707.pdf

[7] NERC, "State or Reliability 2017," June 2017, page 163, available at http://www.nerc.com/pa/RAPA/PA/Performance%20Analysis%20DL/SOR_2017_MASTER_20170613.pdf

[8] Texas Tribune, "An Interview with the CEO of the Texas Grid," February 2011, available at https://www.texastribune.org/2011/02/04/an-interview-with-the-ceo-of-the-texas-grid/; ERCOT, "Review of February 2, 2011 Energy Emergency Alert Event, February 2011," available at http://www.ercot.com/content/meetings/board/keydocs/2011/0214/Review_of_February_2,_2011_EEA_Event.pdf; and PJM, "Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events," May 2014, available at

output as Hurricane Harvey came ashore in August, and all large wind projects in the area came back online once the local power grid was restored. Recent analysis by PJM, the nation's largest grid operator, found that the scenarios in which wind energy provided the majority of electricity were some of the most resilient to unexpected weather events.[9]

Because no energy source cost-effectively provides all grid reliability services at all times, markets allow a valuable division of labor, with each delivering the services it can provide best at that point in time. This leads me to the following recommendations:

1. Rely on competitive markets

Wholesale electricity markets have performed well at providing affordable and reliable electricity. Since markets require open participation with low barriers to entry, any services needed can be competitively procured from all generation sources. The RTOs, FERC, and NERC should continue to competitively procure services through markets without putting their thumbs on the scale for any generation source or technology. We strongly support DOE's call for "creating fuel-neutral markets ... that compensate grid participants for services that are necessary to support reliable grid operations."[10]

2. Focus on reliability needs, not generation sources

Identify and compensate for the reliability services that are needed—flexibility, disturbance ride-through, frequency and voltage support, as well as dependable capacity and energy generation—not the

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http://www.pjm.com/~/media/library/reports-notices/weather-related/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx

[9] PJM, "PJM's Evolving Resource Mix and System Reliability," March 2017, available at http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx

[10] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 126, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

fuel type of the generator or other characteristics that are not reliability services (e.g. having onsite fuel, being physically close to load).

As the Brattle Group explained in a June report, "As some of the coal and nuclear power plants face retirement decisions, focusing on their status as baseload generation is not a useful perspective for ensuring the cost-effective and reliable supply of electricity."[11] FERC, RTOs and NERC are well-equipped to define the services needed to keep the grid reliable and resilient. FERC Chairman Chatterjee correctly cautioned in testimony here last month that "states generally have jurisdiction over the resource mix in their individual states, and that FERC has generally remained resource- and fuel-neutral in fulfilling its core obligations...." To promote competition and innovation, all resources should be compensated for the reliability services they provide and all resources that can provide such services should be allowed to offer them.

3. Do not be distracted by negative prices

Last month's DOE report correctly notes that negative prices "have had almost no impact on annual average day-ahead or real-time wholesale electricity prices" and often occur in remote parts of the grid where they have little to no impact on other power plants.[12] DOE also accurately explains that many types of power plants occasionally cause negative prices, including nuclear and fossil plants, as "Conventional generators also face economic factors that lead them to submit negative bids. Existing

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[11]Brattle Group, "Advancing Past "Baseload" to a Flexible Grid," June 2017, available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498246224

[12] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

nuclear plants in the United States, as well as some fossil units, may bid in during these periods to avoid costly start-ups and shutdowns."

AWEA recently released comprehensive analysis confirming that renewable energy accounts for an extremely small share of the already negligible occurrences of negative prices at retiring coal and nuclear power plants.[13] This data builds on analysis we released three years ago,[14] which demonstrated the trivially small frequency and impact of negative prices in Illinois, and was labeled by then-FERC Commissioner Norris as "compelling."

Our latest analysis examines full-year 2016 price data for all retiring power plants in the main wholesale electricity markets that have a large amount of wind generation: PJM, MISO, SPP, and ERCOT. Across more than 1.8 million data points, which cover all 2016 pricing intervals in the day-ahead electricity market for all retiring power plants in those regions, only 55 instances of negative prices were found (0.003% of prices) that could have been set by a wind project receiving the PTC. The analysis includes market price data for all power plants that have retired since 2012 or have announced plans to retire according to DOE.

Our analysis focused on the day-ahead electricity market (the results bolded below), as that is where nuclear and coal generators sell most if not all of their generation. However, the results show that wind plants almost never set prices in the real-time electricity market either. For more on electricity markets and how prices are set, see the last header under this section.

In PJM and MISO, which account for a large share of all power plants in wholesale markets that are retiring nationwide, only 0.003% of day-ahead market prices at retiring power plants were in a range

[13] AWEA, "Putting the Negative Price Myth to Bed," July 2017, available at http://www.aweablog.org/renewables-grid-putting-negative-price-myth-bed/

[14] AWEA, "The Facts about Wind Energy's Impacts on Electricity Markets," March 2014, available at http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA%20white%20paper-Cutting%20through%20Exelon%27s%20claims.pdf

that could be set by a wind project receiving the federal Production Tax Credit (PTC), as shown on the left side of the table. Occurrences of negative prices that could be wind-related were even less frequent in SPP, at 0.0017% of day-ahead market price intervals. Those occurrences were slightly more common at retiring plants in ERCOT, at 0.06% of price intervals, but it should be noted that there is only one retiring coal power plant in ERCOT.

Market prices at retiring generators, by ISO	Real-Time or Day-Ahead Market	Share of prices that are negative	Prices between -$20 and -$40 /MWh (offer range for PTC + REC wind project)	Average market price	Average price if all -$20 to -$40/MWh prices were $0/MWh	Price change if wind offered $0/MWh
PJM	Real-Time	0.88%	0.12%	$26.41	$26.44	$0.03
	Day-Ahead	0.18%	**0.003%**	$26.8811	$26.8818	**$0.0007**
ERCOT	Real-Time	1.62%	0.03%	$21.7825	$21.7888	$0.0063
	Day-Ahead	0.08%	**0.06%**	$22.635	$22.649	**$0.014**
SPP	Real-Time	2.04%	0.54%	$21.32	$21.49	$0.17
	Day-Ahead	0.59%	**0.0017%**	$21.9965	$21.9969	**$0.0004**
MISO	Real-Time	1.20%	0.14%	$25.413	$25.451	$0.038
	Day-Ahead	0.22%	**0.003%**	$25.6803	$21.6810	**$0.0007**

To underscore the trivial impact of the PTC in setting market prices, the right side of the table shows how prices would change if wind projects receiving the PTC no longer received the credit. In PJM and MISO, conservatively assuming that all negative prices in that range were set by wind projects receiving the PTC, Day-Ahead Market prices at retiring power plants would increase by an average of $0.0007, or 1/13th of a penny per MWh, if operating wind projects no longer received the PTC. Retiring power plants in SPP saw an even smaller impact at 1/25th of a penny, while the one retiring coal power plant in ERCOT saw an impact of around one penny per MWh.

However, it is important to clarify that the PTC does directly reduce consumer electricity costs outside of the electricity market. The PTC and other incentives allow wind projects to offer lower long-term contract prices to customers and the utilities who serve them, which translates into lower electric bills for consumers on a 1:1 basis. However, those contract payments are outside of the wholesale electricity market, so they are not directly factored into the wholesale electricity market prices received by other generators.

In reality, market dynamics are driving retirements

Market changes are benefiting consumers by driving retirement of older, less efficient resources in favor of more efficient resources. The DOE report[15] agrees with a wide range of experts that the primary factors driving power plant retirements and economic challenges for generators of all types are cheap natural gas and flat electricity demand.[16]

Competition from lower-cost gas generation is the primary cause of the economic challenges facing many power plants. DOE's report notes that "The biggest contributor to coal and nuclear plant retirements has been the advantaged economics of natural gas-fired generation."[17] The DOE study also explicitly exonerates renewable generation as a primary cause of retirements, noting that "the data do

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[15] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 113, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

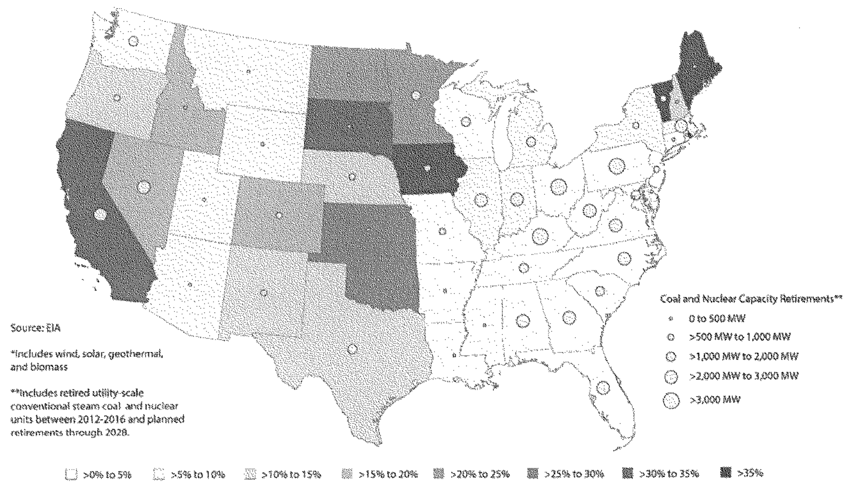
[16] See: Analysis Group, "Electricity Markets, Reliability and the Evolving U.S. Power System," June 2017 http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/ag_markets_reliability_final_june_2017.pdf; R Street Institute, "Embracing Baseload Power Retirements," May 2017, available at http://www.rstreet.org/wp-content/uploads/2017/05/97.pdf; Rocky Mountain Institute, "The Grid Needs a Symphony, Not a Shouting Match," June 2017, available at https://rmi.org/news/grid-needs-symphony-not-shouting-match/; Utility Dive, "The state of US wholesale power markets: Is reliability at risk from low prices?," May 2017, available at http://www.utilitydive.com/news/the-state-of-us-wholesale-power-markets-is-reliability-at-risk-from-low-pr/443273/

[17] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 13, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

not show a widespread relationship between [variable renewable energy] penetration and baseload retirements...While concerns exist about the impact of widespread deployment of renewable energy on the retirement of coal and nuclear power plants, the data do not suggest a correlation."[18]

The following map, compiled from Department of Energy data, shows that most retiring coal and nuclear plants are in regions that have little to no renewable generation, confirming that renewable energy or pro-renewable policies cannot be the primary factor driving those retirements.

Recent and Planned Coal and Nuclear Retirements
and 2016 U.S. Renewable Energy* Share of Electricity Generation, by State



Rather, the primary factor driving power plant retirements appears to be low-cost shale gas production undercutting relatively high cost Appalachian and Illinois Basin coal in the Eastern U.S., as shown below. In the regions shaded red in the map, the fuel cost of producing electricity from natural gas is significantly lower than the fuel cost of coal power plants, explaining why utilities in those regions are

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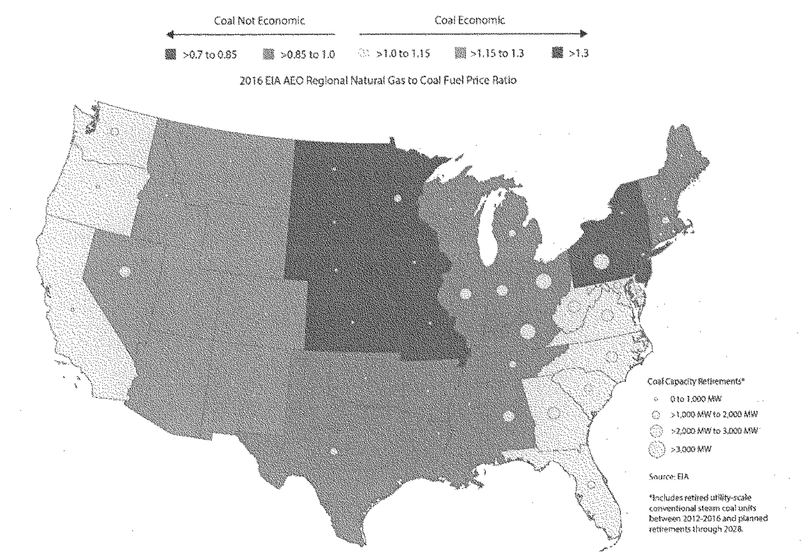
[18] *Ibid.*, page 50

moving from coal to natural gas generation.

Recent and Planned Coal Retirements and Economics of Coal versus Natural Gas, by Region



In short, as then-FERC Commissioner John Norris concluded after looking into the matter, focusing on negative prices is a "distraction," while "transmission development is the better, and more proactive, solution."[19] This brings me to my fourth and final recommendation.

4. Promote transmission infrastructure investment

Building a more robust transmission system is the single most effective tool for improving resiliency and providing customers greater access to all low-cost sources of energy, whether nuclear, renewable, or fossil. NERC has noted that renewable integration is a primary driver for only 16 percent of planned

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[19] Commissioner John R. Norris Statement, May 2014, available at https://ferc.gov/media/statements-speeches/norris/2014/05-15-14-norris.asp

transmission, demonstrating the range of benefits transmission provides.[20] A strong, integrated power grid would provide the same vast benefits as our interstate highway system: creating resilient infrastructure that is critical during emergencies, while on a daily basis allowing the most competitive businesses to deliver their low-cost goods to consumers. Unfortunately, in many regions today's grid is not a national network of four-lane highways but a balkanized tangle of dirt roads.

Transmission benefits all low-cost generation resources as it allows their low-cost power to reach customers. Like any market, electricity markets are more competitive when there are fewer barriers to entry, and a congested grid can be a barrier to competitive electricity markets. For this exact reason, Texas has always had some of the strongest pro-transmission policies in the country. As ERCOT board member Peter Cramton recently explained, "One thing in favor of strengthening transmission ... is that it's pro market. It allows a larger set of generators to compete in a more robust marketplace. You don't always want to throw money at transmission, but at same time, you have to recognize it's transmission that's enabling the market."[21]

A more robust transmission system would prevent almost all occurrences of negative prices, whether caused by nuclear, coal, or renewables. The DOE report accurately notes that most instances of negative pricing have been observed at "constrained hubs that feature a relatively large amount of [variable renewable energy] and/or nuclear generation."[22] Any instances of wind-related negative prices are typically caused by transmission constraints on isolated parts of the grid. Because there are few if any

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[20] NERC, "Potential Reliability Impacts of EPA's Proposed Clean Power Plan," November 2014, page 20, available at http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Potential_Reliability_Impacts_of_EPA_Proposed_CPP_Final.pdf

[21] RTO Insider, "ERCOT Board OKs Rio Grande Valley Fixes," June 2016, available at https://www.rtoinsider.com/ercot-board-rio-grande-valley-28040/

[22] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

conventional power plants on these remote parts of the grid, these events have little to no impact on other generators.

Grid operators have explained that transmission is a key solution for making electricity more reliable and affordable, and that investments in transmission pay for themselves many times over.[23] As DOE's report documents, "Transmission investments provide an array of benefits that include providing reliable electricity service to customers, relieving congestion, facilitating robust wholesale market competition, enabling a diverse and changing energy portfolio, and mitigating damage and limiting customer outages (resilience) during adverse conditions. Well-planned transmission investments also reduce total costs. SPP analyzed the costs and benefits of transmission projects from 2012–2014 and found that the planned $3.4 billion investment in transmission was expected to reduce customer cost by $12 billion. This yielded an estimated benefit of $3.50 for every dollar invested in the region."[24]

Among the DOE report's primary recommendations are that "DOE and related Federal agencies should accelerate and reduce costs for the licensing, relicensing, and permitting of grid infrastructure," and that "DOE should review regulatory burdens for siting and permitting for generation and gas and electricity transmission infrastructure and should take actions to accelerate the process and reduce costs."[25] As DOE notes, "natural gas pipelines can be built more quickly than electric transmission lines (in most states) because they have a comparatively streamlined permitting process."[26] Congress can greatly expedite infrastructure investment by applying the successful permitting policies used for natural gas

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[23] SPP, "The Value of Transmission," January 2016, available at https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf; MISO, "MTEP14 MVP Triennial Review," September 2014, available at https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MTEP14%20MVP%20Triennial%20Review%20Report.pdf

[24] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 75, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[25] *Ibid.*, page 127

[26] *Ibid.*, page 37

pipelines to transmission infrastructure. NERC's CEO testified here last month that "policymakers should seek alternatives to streamline siting and permitting of transmission."

In sum, we support the objectives of maintaining reliability and resilience, and urge that they be promoted through free and open markets, with a focus on needed reliability services, not source, and a program to promote transmission infrastructure.

Mr. UPTON. Thank you.

Next we are joined by Steve Wright, GM for Chelan Public Utility District on behalf of the National Hydropower Association.

Welcome to you, sir.

STATEMENT OF STEVE WRIGHT

Mr. WRIGHT. Mr. Chairman, Ranking Member, thank you for the invitation to appear to today. My name is Steve Wright and I'm the general manager at Chelan County, Washington Public Utility District.

Chelan has roughly 2,000 megawatts of hydropower. I'm also representing the National Hydropower Association.

From 2000 to 2013, I was the administrator and chief executive officer of the Bonneville Power Administration, serving under three presidents.

My duty today is to describe the value that hydropower provides supporting reliable service to our Nation's electric consumers.

This should be one of the easier assignments given to any congressional witness, given the vast array of reliability, cost, and air emission benefits hydropower provides.

It's important to understand that maintaining reliability involves many complex products and services. These include energy, peak capacity, regulation or frequency response, spinning and non-spinning reserve, voltage control, black start capability and inertia, and particularly important in a world increasingly reliant on variable energy resources, there is a need for flexible capacity.

Many generating resources can provide multiple characteristics necessary for reliability. But hydropower is best positioned to provide them across the board.

In life we usually have to face a trade-off between quality and cost. Not so with respect to hydropower. Hydropower is generally the least-cost resource available in the marketplace.

Hydropower also produces zero air emissions and represents a least-cost path to meeting both our reliability and emissions national objectives.

The key challenge for hydropower in the coming decade is the lack of policy attention it has received. Hydropower is, for the most part, taken for granted in the marketplace.

This results in significant potential missed opportunities for both refurbishment and new construction. There is a need for a massive reinvestment in what is an aging fleet.

Most hydropower capacity in this country was built from 1930 to 1975. For the most part, the engineering on these projects was excellent and the projects are outliving design life.

We are, however, already entering a period where there is a need to refurbish tens of thousands of megawatts of hydropower capacity.

The decision whether to invest in hydropower refurbishment can be described simply. The cost of refurbishment is compared against other alternatives, taking into consideration prices for energy, capacity, and environmental attributes.

In today's market, energy prices are currently quite low, in part due to the Federal tax policy. Capacity markets are not providing prices commensurate with what's necessary for refurbishment or, in some cases, even maintenance of existing plants.

This is in part due to the difficulty of establishing markets and regulatory regimes for issues such as resource adequacy that address the specific services and actions necessary to maintain reliability.

And the environmental attribute markets are not providing pricing commensurate with aggressive goals or emissions reductions.

New hydropower resources and even many refurbishment projects face a challenging investment environment, given today's pricing. And while low prices sound good for consumers, it would not be if it leads to shortage, price volatility, and reliability problems.

Unfortunately, I lived through the West Coast energy crisis when we experienced fundamental imbalance between supply and demand. Our policy should be developed to assure there is adequate supply to achieve high reliability and reduce the risk of extreme price excursions.

NHA's Jeff Leahey provided testimony before the Senate Energy Committee that identified Federal policy that needs to evolve in the following ways to support hydropower.

We need relicensing reform. The, roughly, 10 years required for relicensing does not compare favorably against the permitting requirements for other generating resources. It needs similar tax treatment to other zero-emission-generating resources and we need further support for research and development.

And I would add to that list support for adequate capacity prices to encourage cost-effective investment. The fundamental problem addressed last week by the Department of Energy is despite best efforts in various regions, markets to this point have not been structured to provide adequate compensation for the various services necessary to assure long-term resource adequacy, reliability, and resiliency.

Underlying Federal or State tax and other incentive policies tend to make robust market design even more difficult. The capacity reliability challenge will vary by region, though.

For example, in the West, with our plethora of variable energy resources, our biggest challenge is providing flexible capacity.

Because it is complex, it will be difficult to address in an expedited process or with a focus as limited as the concept of base load resources. But at the same time, the problem of price formation being inadequate to address reliability needs is real.

Policies that assure adequate resource supply for reliability deserve the attention of policy makers.

So in conclusion, hydropower is the Nation's premier generation source for reliability, cost, and emissions perspective.

Due to its quiet long history and relative success, it has been taken for granted in Federal public policy debates. Given what is at stake, hydropower deserves more focus.

Thank you for the time.

[The prepared statement of Mr. Wright follows:]

Written Testimony of

Steve Wright
General Manager of Chelan County Public Utility District No. 1
Wenatchee, Washington

On behalf of

The National Hydropower Association

Before the

House Energy and Commerce Committee
Subcommittee on Energy

Hearing on "Powering America: Valuing Reliability in a Transforming Electricity Industry"

October 3, 2017

Executive Summary

- Hydropower is the premiere electric generating resource. It is low cost, emission-free and, unlike any other generating resource, can provide *all* components of reliability, including: energy, peak capacity, voltage support, regulation, spinning and non-spinning reserves, storage, black start capability, and inertia.

- As the electric grid integrates more and more variable energy resources, hydropower's ability to provide peaking capacity, flexibility and storage are increasingly important.

- Hydropower projects have a long lifespan, with major equipment lasting fifty years or more. The levelized cost of electricity from existing large hydropower is low and new hydropower can be very competitive, though it is at a disadvantage compared to other renewables due to the inequity in federal tax incentives.

- Hydropower represents a "least cost" path to addressing emissions concerns.

- Yet hydropower faces several key challenges:

  - There is a massive need for reinvestment in the existing aging fleet. The largest hydropower projects were built between 1930 and 1975 and many are undergoing, or will need to undergo, major rehabilitation.

  - Market rules generally undervalue operational flexibility, which is a prime attribute of hydropower. Because the services are not appropriately compensated, these valuable attributes are not optimized and potentially wasted.

  - Public policy has created programs, such as renewable portfolio standards, that tend to exclude and devalue hydropower compared to other renewable or carbon free resources.

  - The hydroelectric relicensing process can take 10 years or more to complete, with process costs representing a significant portion of a licensee's overall costs to obtain and implement a 30-50 year license. In the next 15 years, over 500 hydroelectric projects license will expire and require renewal by the Federal Energy Regulatory Commission (FERC).

  - Costs and delays associated with hydropower licensing can affect the timing and level of ongoing investments. In addition, the operational capability of hydropower – its major benefit for reliability – is often limited or diminished in order to carry out the commitments required to obtain a new license.

- Legislation to improve the licensing process, such as H.R. 3043, the Hydropower Policy Modernization Act of 2017, and the hydropower provisions in S. 1460, the Energy and Natural Resources Act of 2017, will help preserve and grow the nation's hydropower fleet.

Introduction

Good morning Chairman Upton, Ranking Member Rush, and members of the Committee. I am Steve Wright, General Manager of the Chelan County Public Utility District in Wenatchee, Washington. I am testifying on behalf of the National Hydropower Association (NHA), a nonprofit national association dedicated to promoting clean, affordable, renewable U.S. hydropower. NHA represents more than 220 companies, from Fortune 500 corporations to family-owned small businesses. Its members include both public and investor-owned utilities, independent power producers, developers, equipment manufacturers and other service providers, and academic professionals.

Chelan PUD is a member of NHA. We own and operate three hydroelectric projects in Washington State, Rocky Reach (P-2145), Rock Island (P-943) and the Lake Chelan Project (P-637). Combined, these projects generate approximately 10 million megawatt hours of clean, reliable, emission-free electricity annually – enough to power a city of one million people. Before being named as General Manager at Chelan PUD in 2013, I was the Administrator of the Bonneville Power Administration, a position I held for more than 12 years, serving under three U.S. presidents. In the Pacific Northwest, reliable and affordable hydropower is the lifeblood of the economy and I am pleased to be here to discuss its importance to the U.S. electric system.

Hydropower is a Premier, Multi-Purpose Renewable Resource

In the United States, almost 2,200 hydropower plants with a total capacity of 80 gigawatts (GW) provide about 6 percent of the nation's electric generation. These plants also represent almost half of the country's renewable energy generation. Meanwhile, an additional 42 hydropower pumped storage plants with approximately 22 GW of capacity provide 97 percent of U.S. energy storage.[1] A 2016 report from

[1] Please see the testimony submitted by the National Hydropower Association before the Energy Subcommittee on May 3, 2017 and the Senate Energy and Natural Resources Committee on March 14, 2017 (also attached) for a full description of

the Department of Energy, Hydropower Vision[2], projects that hydropower potentially could grow by 49 GW by 2050. Hydropower's infrastructure helps to manage and balance river flow for flood control, drought management, water supply, irrigation and ecosystem purposes. It also protects air quality by avoiding greenhouse gas emissions from fossil fuels in the electric and transportation sectors. And, it is capable of providing *all of the services* generally recognized as crucial for maintaining electric grid reliability.

Hydropower Serves the Grid

There are many characteristics of generating resources that are necessary to maintain grid reliability. But there is only one generating resource that can effectively address all the reliability requirements. The graphic below compares a large hydropower project to other generating resources across a broad spectrum of energy, capacity and ancillary services. Although each plant is different and some (particularly the larger projects) have greater capabilities than others, here are hydropower's reliability characteristics:

- *Annual Energy*

  Even though streamflows can vary, hydropower is a reliable resource that produces energy throughout the year. Electric power systems use energy from hydropower to both avoid building new generation and reduce the use of existing fossil fuel fired resources.

- *Peak Capacity*

  Hydropower systems are generally built to take advantage of high streamflows and hence have available capacity that can be called upon at virtually no additional cost to meet system peaks due to

hydropower's contribution and growth potential, along with a discussion of the licensing issues, regulatory inefficiencies and tax treatment that present challenges for preserving and growing the nation's hydropower fleet.

[2] Hydropower Vision, A New Chapter for America's 1st Renewable Electricity Source. U.S. Department of Energy, 2016. Overview. https://energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source

low or high temperatures. Meeting these extreme events is one of the most significant costs for any electric power system

- *Voltage Support and Reactive Power*

  Reactive power is necessary to keep voltage at levels necessary to maintain reliability under a wide range of conditions. Hydro generators are very well suited by design and inherent capability to maintain system voltage, providing substantial increase or decrease in voltage as necessary. No other generation source is better able to provide reactive power. Some hydropower units can produce reactive power even when not producing power (MWs).

- *Regulation (Frequency Response)*

  In order to preserve grid reliability, supply and demand must remain in balance – not only hour to hour, but second to second. Every electric system must maintain generation that can react quickly to assure loads and resources are constantly in balance. Hydropower projects are best suited to provide this service because it can be accomplished merely by allowing more water to pass through turbines using automatic generator control or simply by relying on the large inertia of the machines.

Sample resource characteristics of electric power sources[3]

	Peak capacity	Annual energy	Regulation	Spin reserves	Non-spin reserves	Storage	Inertia	Black Start
Hydroelectric (large project)	yes, water dependent	yes, water dependent	yes	yes	yes	yes	yes	yes
Gas (CCCT)	yes	yes	yes, could be limited	yes, could be limited	yes, could be limited	no	yes	yes
Gas (frame SSCT)	yes	yes, could be limited	yes, could be limited	yes, could be limited	yes, could be limited	no	yes	yes
Gas (flexible SSCT)	yes	yes, could be limited	yes	yes	yes	no	yes	yes
Coal	yes	yes	limited	limited	no	no	yes	no
Nuclear	yes	yes	no	no	no	no	yes	no
Biomass	yes	yes	yes, could be limited	yes, could be limited	yes, could be limited	no	no	no
Geothermal	yes	yes	yes	yes	yes	no	no	no
Solar, PV	location dependent	yes, location dependent	yes, limited by energy potential	yes, limited by energy potential	yes, limited by energy potential	no	no	no
Solar, thermal	limited to yes	yes, location dependent	yes, limited by energy potential	yes, limited by energy potential	yes, limited by energy potential	yes	no	no
Wind	location dependent	yes, location dependent	yes, limited by energy potential	yes, limited by energy potential	yes, limited by energy potential	no	possibly, using synthetic product	no
Demand response	reduces peak need	no	program dependent	program dependent	program dependent	no	no	no
Energy efficiency	reduces peak need	reduces energy need	no	no	no	no	no	no
Batteries	yes	uses energy	yes	yes, depends on size	yes, depends on size	yes	no	yes, limited by size

[3] Based on Value of Hydropower to the Northwest Grid, Pacific Northwest Utilities Conference Committee (PNUCC). November 2016. P. 22. http://www.pnucc.org/sites/default/files/Value%20of%20Hydro%20PNUCC%20Nov%2022%202016.pdf as amended by Chelan PUD. September 2017. This table is for illustrative purposes only – it is not a definitive guide to resource characteristics. Utilities and other organizations may assume different characteristics from the same resources.

- *Spinning Reserve*

  On a sub-hourly basis, generating units are maintained in a "spinning" status ready to rapidly react to unanticipated increases in load or decreases in generation across the power system. Spinning reserves are there to respond to load changes as fast as 10 seconds and up to 10 minutes. These resources stabilize system frequency during emergency operating conditions and unforeseen load swings. Because hydropower projects generally have multiple turbines that are not fully loaded, hydropower is a natural fit for supplying reserves including over extended periods of time.

- *Non-Spinning Reserve*

  Non-spinning resources are units that are able to quickly turn on and provide power in less than 10 minutes, maintaining output for at least two hours. Hydropower can also provide this service using less than fully loaded turbines.

- *Storage*

  Many large conventional hydropower projects can provide storage capability through the use of reservoirs, providing opportunities to better balance loads and generating resources. It's important to note, however, that pumped storage is particularly well positioned to reduce curtailment of excess generation by providing load and energy storage. Pumped storage includes both a load (to pump water uphill) and generation. These units can rapidly increase generation or load as needed for grid stability and economic efficiency. Storage gives hydropower projects the fuel (water) to provide all the various reliability services.

- *Black Start Capability*

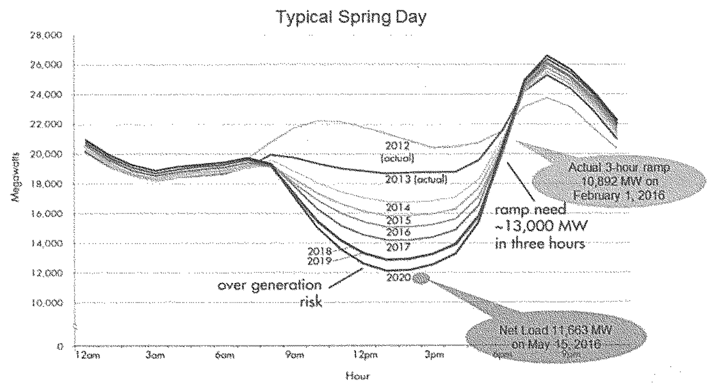
  During outages, hydropower can help restart the power system without support from the transmission grid, enabling other generators to come online. Hydro resources can normally be operational very quickly to support grid restoration. They generally have adequate fuel supply (the reservoir), and can provide a sustained response.

- *Inertia*

  Hydropower units are also a source of inertia that is important for avoiding widespread blackouts. Inertia provided by the large rotating mass of traditional generators has historically stabilized the Western Interconnection's frequency by slowing frequency decline and, with the help of power system stabilizers, dampening the cascading oscillations that can occur when there is a disturbance (such as the sudden loss of large generation). Hydropower resources have a lot of mass that provides significant inertia.

- *Flexible Capacity*

  As the grid becomes increasingly reliant on variable energy resources, there is an increasing need for flexible capacity that can respond, given the production uncertainty of resources such as wind and solar. Many hydropower projects are flexible enough to move generation around during the day to provide a dispatchable generation to assure loads and resources stay in balance. As an example, the California grid depends on flexible resources like hydropower to come online in the afternoon when the sun sets, limiting solar power generation. During a typical spring day, resources like hydropower must ramp up to meet demand very quickly in the evening after net load has bottomed out during the middle of the day. The graphic below from the California Independent System Operators (CAISO) depicts this phenomenon as the now-famous "duck curve". Unlike fossil fired resources, hydropower can be available to respond to change in net load (load minus variable energy resources) without burning fuel to be kept in a ready state.



Source: CAISO, 2016.

<u>Hydropower Is Cost-Effective</u>

Generally, in life we have to face a trade-off between quality and cost. Not so with respect to hydropower. Hydropower is an affordable and low-cost resource, benefiting consumers through lower electricity costs. The projects are long-lived, with major equipment such as turbines and generators lasting 30 – 50 years. With costs spread out over the life of the project, hydropower has a relatively low levelized cost of electricity (LCOE). New hydropower is also cost-competitive, particularly hydropower added to currently non-powered dams, though disparate tax treatment and the lack of certainty are issues. These can have a significant impact on the ability of developers to finance projects.

In addition to being a low-cost generating resource, hydropower is a least-cost method of addressing carbon emission concerns. Generating with hydropower produces no nitrogen oxides (NOx) or sulphur oxides (Sox); no mercury or particulate matter; and no greenhouse gases. As the nation increasingly confronts the societal costs of air emissions, hydropower represents a least cost path to meeting both our reliability and air emissions objectives. By utilizing hydropower, utility planners can help achieve the simultaneous goals of least cost planning for load and emissions reductions.

Hydropower Faces Challenges

A variety of economic factors can affect the timing and extent of investments for hydropower licensees. These include forecasted energy prices, capacity and ancillary services markets, relicensing requirements, federal and state policies that may disadvantage hydropower, and tax treatment. Hydropower is facing challenges that could affect the continued viability of existing projects and new project development.

- *Aging Fleet*

As acknowledged in the Department of Energy's 2016 Hydropower Vision report, "America's first renewable electricity source, hydropower, has been providing flexible, low-cost, and low-emission renewable energy for more than 100 years."[4] Hydropower, for the most part, is taken for granted. However, there is a massive need for reinvestment in the existing aging fleet. Most of the largest hydropower projects were built between 1930 and 1975 and many are undergoing, or will need to undergo, major rehabilitation. At Chelan PUD, we have begun upgrading the Rock Island Hydroelectric Project – the first dam on the Columbia River. Although it had a design life of 50 years, it has been operating since the first power house was completed in 1933 (with a capacity expansion in 1952-53) and the second powerhouse was completed in 1979. In other words, the project has operated for nearly *85 years with much of the original components.* But last year, we discovered that the original turbine blades on four units have stress fractures that will require replacement of the entire turbine unit. This type of event is happening up and down the Columbia in a region where roughly 60 percent of the electricity is provided by hydro-turbines.

Extending the life of the Rock Island project will likely require an investment of roughly a half billion dollars before the current license expires in 2028. This anticipated work includes rehabilitation project of

[4] Hydropower Vision report, Message from the Director.

Rock Island Powerhouse 1 that is expected to cost roughly a quarter billion, as well as a modernization of Rock Island Powerhouse 2 at an estimated $240 – $400 million, which is expected to begin in 2018. The decision whether to replace the units can be described rather simply. The cost of replacement must be compared to other alternatives, including market purchases. When weighing hydropower investments, we will take three primary values taken into consideration: energy, capacity and carbon. The higher these values, the more likely hydropower reinvestment will occur. At Chelan PUD, we sell a significant portion of our hydropower on the market. Hence, we have insights into the value being currently offered in western power markets and how these factors can affect hydropower investment.

- *Market Valuation*

Energy values in the western power markets have fallen dramatically in the last 5 years due to low natural gas prices and the infusion of variable energy resources (primarily wind and solar) resulting from renewable portfolio standards adopted by western states. Price reductions due to a surplus of supply, economies of scale, and federal production and investment tax credits for wind and solar have had a significant effect on lowering wholesale energy prices. At times there is so much energy available that plant owners are willing to pay purchasers to take energy in order to receive the tax credits. These factors reduce the revenues received by hydropower owners while the hydro plants are still providing valuable reliability services.

In the west, capacity is generally sold in bilateral markets rather than in organized markets as in other parts of the country. Capacity is not a single product, but many different products that are necessary to achieve high reliability. In some cases, such as with frequency response, there are evolving markets that are beginning to provide value for capacity. But for the most part, capacity products tend to be undervalued when there is an energy surplus, as is being experienced in the west. The Department of Energy's Hydropower Vision report came to a similar conclusion when it commented that "not all benefits provided by hydropower facilities are readily quantifiable or easily attributable to hydropower in a market framework" and "[I]t's possible that no value or inadequate value may be placed on some services, such as those provided by hydropower generators with characteristics that allow for rapid and precise response to instability in the grid."[5]

Today's power prices are also influenced by carbon prices and other markets for environmental attributes. Hydropower marketing is complicated by inconsistent treatment of hydropower as a renewable from state to state. Renewable portfolio standards often do not treat hydropower equitably with other carbon free and renewable resources. These can include restrictions on qualifying hydropower based on size, operations, or placed in service dates. Carbon markets present some opportunity for hydropower. For example, California has recently extended its cap-and-trade market through 2030. As west coast power markets are heavily influenced by the California market, the current carbon price does have an impact on wholesale electricity prices. But at $15 a ton, it is far below the price required to achieve the level of carbon reduction sought by west coast states.

The net effect of today's projected energy, capacity and carbon values resulted in a decision by Chelan PUD to pursue refurbishment of its Rock Island facilities. But the conclusion on the economics was closer than one would have expected for a dam that is already constructed. Further declining prices place existing hydropower at risk. New hydropower resources would face a more difficult challenge, particularly given the extended periods required for hydropower relicensing.

While low wholesale electricity prices sound good for consumers, a downside exists if certain generating resources are expected to provide services with inadequate compensation – particularly since increased reliability services can provide wear and tear on hydropower units. Inadequate compensation can lead to inadequate investment, resulting in supply/demand imbalances. Such imbalances were the

[5] Hydropower Vision Report. Section 2.3.1.

root cause of the 2001 west coast energy crisis, which substantially harmed west coast electricity consumers. For hydropower, concerns about inadequate compensation will come into sharper focus as reinvestment decisions are made in advance of relicensing. The Department of Energy's Hydropower Vision report states that "Enhancing existing market approaches and developing new approaches can help facilitate full recognition and compensation of the suite of grid services, operational flexibility, and system-wide benefits offered by new and existing hydropower."[6] NHA agrees with this conclusion and believes that full recognition of hydropower's benefits for grid reliability and system stability will improve hydropower economics.

- *Federal Policy*

As described in the testimony of Jeffrey Leahey, Deputy Executive Director of NHA before the Senate Energy and Natural Resources Committee on March 14, 2017 (testimony attached), federal policy needs to evolve to support the reinvestment and development of low cost hydropower. Specifically:

➢ Licensing reform. Hydropower has the longest, most complex development timeline for project relicensing or new project approvals of any of the renewable energy technologies, with some projects taking 10 years or longer form the start of the licensing process through construction to being placed-in-service. See *Leahey*, beginning page 12. In addition to these process reforms, the Federal Energy Regulatory Commission should encourage hydropower investments by crediting a licensee's "early actions" when considering the term of the next project license, as this can create more certainty for licensees approaching license renewal. To address many of these process issues, NHA supports congressional efforts to improve the licensing process, including H.R. 3043, the Hydropower Policy Modernization Act of 2017, and the hydropower provisions in S. 1460, the Energy and Natural

[6] Ibid, Page 29.

Resources Act of 2017. NHA is pleased the Committee passed H.R. 3043 in June and we look forward to the legislation advancing.

- Tax treatment. Disparity in the level and duration of tax credits for hydropower and other renewable resources presents an inequity for hydropower development. See *Leahey*, page 15.
- Research and Development. While federal support for hydropower research and development has been improving over the last few years, the Water Power program is still one of the smallest in the Office of Energy Efficiency and Renewable Energy. See *Leahey*, page 15.

Conclusion

Hydropower is the nation's premier renewable resource from a cost, emissions and reliability perspective. Due to its quiet long history and relative success, it has for the most part been taken for granted in federal public policy debates. Given the aging infrastructure and potential for new development, it deserves more focus in the development of federal energy policy. As the Congress works to address our energy and infrastructure needs, NHA encourages policies that promote reinvestment, value reliability services, and improve the licensing process to facilitate hydropower's future contributions to electric reliability. Continued investment and re-investment in the system is critical to our energy future and national security. Hydropower's relative value is increasing even as energy prices fall.

- It is a capacity resource as fossil generation shuts down;
- It is flexible enough to follow load changes;
- It provides ancillary services to support grid reliability;
- It is a low-cost source of emissions-free energy; and
- It provides products increasingly critical to reliability as the use of variable energy solar and wind expands.

NHA looks forward to working with you to better allow hydropower to contribute to meeting our nation's economic and environmental objectives. Hydropower is not just a legacy resource. Its owners and operators are planning hydropower's next 100 years of service to this country, and it can grow with adequate compensation and appropriate regulatory policy. I thank the Committee for this opportunity to testify and I look forward to answering your questions.

Attachment – Supplemental Materials

NHA
National Hydropower Association

Written Testimony of

Jeffrey Leahey
Deputy Executive Director

On behalf of

The National Hydropower Association

Before the

Senate Energy and Natural Resources Committee
Hearing to Receive Testimony on Opportunities to Improve American Energy Infrastructure

Regarding

An Overview of Hydropower, its Benefits, and Policy Issues

March 14, 2017

Written Testimony of Jeffrey Leahey, Deputy Executive Director, National Hydropower Association

Executive Summary

1. In the last several years, hydropower has provided approximately 6 percent of all U.S. electricity generation and nearly half of renewable generation. By 2030, approximately 400 projects representing 18,000 MW of capacity of the existing system will be up for relicensing.

2. Hydropower has significant untapped growth potential, particularly at existing infrastructure and with low impact projects, such as capacity additions at current hydropower facilities, adding generation to non-powered dams, and closed-loop pumped storage, among others. The Department of Energy's recent Hydropower Vision Report estimates that close to 50 GW of new capacity is available by 2050, with the right conditions and policy support in place.

3. New hydropower project development, as well as the relicensing of existing projects, faces a variety of obstacles. These include: a regulatory process that can be modernized to increase coordination and reduce unnecessary duplication, delays and costs; a lack of valuation of grid security and reliability services; and inequitable treatment and recognition under renewable energy tax incentives and other renewable/clean energy programs, including federal R&D funding to support new technologies. Combined, these issues are impacting hydropower competitiveness and creating unnecessary challenges that hold back growth.

4. NHA supports policies to address regulatory inefficiencies and to improve coordination in the overall hydropower project approval process and calls on Congress and the Administration to address this and other energy and market policy issues that limit investment in hydropower infrastructure. And, we believe this can all be done in ways that promote the hydropower resource while protecting environmental values.

5. Hydropower has a critical role to play in meeting our nation's energy, environment, and economic objectives. The benefits from this resource are many – low-cost, reliable, base load renewable electricity, along with additional ancillary grid services (load following, frequency response, energy storage, etc.) – services that will allow our country to add significantly to our national portfolio of renewable, clean energy resources.

6. Finally, as the Congress works to address our energy and infrastructure needs, whether that be on a new national infrastructure program or further work on an energy bill, policies that support the preservation of the existing hydropower system and promote the deployment of new projects (for all categories of water power technologies) must be included. A greater recognition that our hydropower infrastructure is incredibly valuable is needed, and continued investment and re-investment in the system is critical to our energy future and national security.

Introduction

Good morning Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. I am Jeffrey Leahey, Deputy Executive Director of the National Hydropower Association (NHA). I am pleased to be here to discuss the importance of hydropower to the U.S. electric system, the untapped growth potential across the various sectors of the industry, and the policy issues that need to be addressed to fully realize that growth.

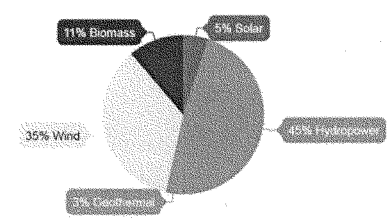
As background, NHA is a nonprofit national association dedicated to promoting clean, affordable, renewable U.S. hydropower – from conventional hydropower to pumped storage to marine energy to conduit power projects. NHA represents more than 220 companies, from Fortune 500 corporations to family-owned small businesses. Our members include both public and investor-owned utilities, independent power producers, developers, equipment manufacturers and other service providers, and academic professionals.

U.S. Hydropower Statistics

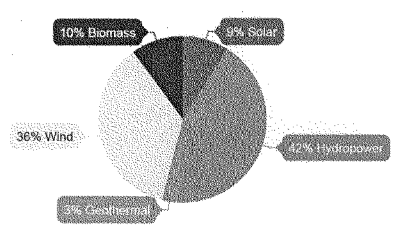
Currently, the U.S. conventional hydropower fleet is made up of almost **2200 individual plants** with a total capacity around **80 GW**. In the last two years, these plants provided approximately **6 percent** of all U.S. electricity generation and **almost half** of all renewable electricity generation – making hydropower the single largest provider of renewable electric power in our country. Looking over the long term, hydropower has supplied a cumulative 10 percent of U.S. electricity generation over the past 65 years (1950-2015), and 85 percent of cumulative renewable power generation over the same time period.

In addition to the conventional hydropower system there are an additional **42 hydropower pumped storage plants** with approximately **22 GW** of capacity – projects that make-up almost all, **97 percent**, of energy storage in the U.S. today.[7]

2015 Sources of Renewable Electricity Generation



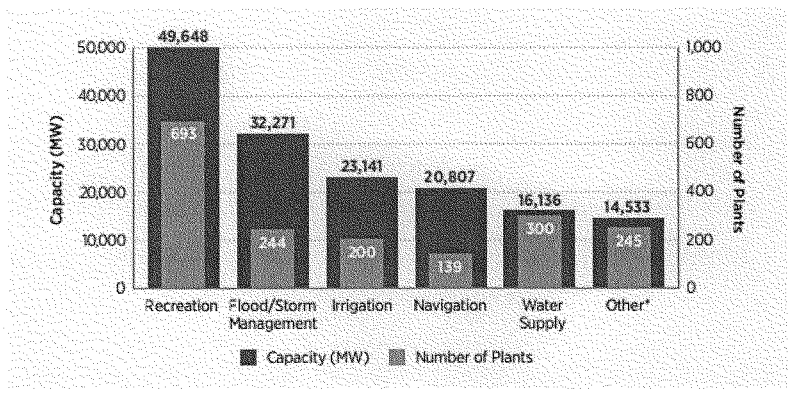
2016 Sources of Renewable Electricity Generation



[7] 2016 Hydropower Vision Report, Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind and Water Power Technologies Office, Executive Summary P. 9. https://energy.gov/sites/prod/files/2016/10/f33/Hydropower-Vision-Executive-Summary-10212016.pdf

Hydropower generation is a clean air resource and avoids millions of metric tons of carbon emissions each year. In fact, regions that rely on hydropower as a primary energy source (like the Northwest) reap the benefits of significantly cleaner air with some of the lowest carbon intensity rates in the country.

In addition to this clean and renewable energy, hydropower infrastructure provides other important benefits, including managing river flow for aquatic species and habitat protection, flood control and drought management, water supply, irrigation and more, as the chart below illustrates.[8]



Note: The use categories are not mutually exclusive; a given dam can be included in more than one category. The data include only powered dams.
Source: Uria-Martinez et al. 2015 [2]

Figure 2-11. Total capacity and number of plants for six separate uses (illustrated by the blue bars) of existing hydropower dams and reservoirs

The next map below was developed by the Department of Energy (DOE) through Oak Ridge National Laboratory (ORNL) and provides a visual representation of the size and location of projects for both the federal and non-federal hydropower systems. Existing hydropower assets are located in all but two states (Delaware and Mississippi), though every state receives the benefit of the clean renewable generation that these projects provide.

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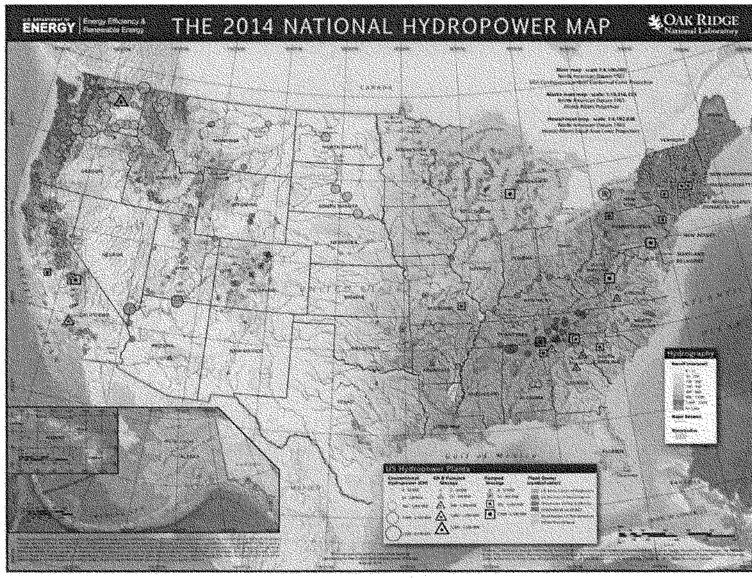
[8] Hydropower Vision Report, Chapter 2, Page 83.



The contributions of the existing hydropower fleet to the electric grid are many (base load power, peaking generation, load-following, energy storage, reliability and more). With the need for more of these benefits and services, as the nation strives to become more energy independent, NHA has seen the hydropower industry grow and expand in recent years.

In fact, the United States experienced a net capacity increase of **1.4 GW**[9] from 2005 to 2013, enough to power over half a million homes[10]. FERC has reported an additional 260 MW of capacity being placed in service since then, with even more projects in licensing or in the construction phase today. And this number could significantly increase with a modernized regulatory approval process that currently takes years longer than that of other renewable resources – in some cases licensing can take 10 years or longer.

In addition, hydropower projects bring multiple economic benefits to the communities in which they are located and those that they serve. To start, the industry itself currently employs a sizable

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[9] 2014 Hydropower Market Report, Executive Summary P. VI.

[10] An Assessment of Energy Potential at Non-Powered Dams in the United States, Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind and Water Power Technologies Office and Oak Ridge National Laboratory, April 2012, Executive Summary P.VII, Footnote 1. http://nhaap.ornl.gov/sites/default/files/NHAAP_NPD_FY11_Final_Report.pdf

workforce. 143,000 jobs are created just from the continued operation and maintenance, as well as upgrades, of the existing system, with additional employment opportunities gained in the pursuit of new project development and deployment.[11]

One recent example that demonstrates the jobs benefit is AMP Public Power Partners of Ohio. AMP is building 4 new hydropower projects on existing Corps of Engineers' dams on the Ohio River (3 are completed and 1 is still under construction). The company reports that approximately 1800 construction jobs were created over a 4 year construction window, with the operation of the projects providing an additional 50 permanent jobs. Another example is Missouri River Energy Service's Red Rock project on the Des Moines River near Pella, Iowa, currently under construction at a Corps of Engineers dam. The company estimates that 250 workers will be needed on site through 2017-2018.

On top of this, the access to low-cost, reliable clean power is attracting many companies to regions with hydropower. For example, major high-tech companies like Google, Facebook, and Yahoo require large, energy-intensive data centers to drive their businesses. Specifically, in September 2010, Yahoo opened a new facility in Lockport, New York to utilize hydropower provided by the New York Power Authority. And again, in 2013, New York officials cited the importance of low-cost hydropower in Yahoo's decision to expand the Lockport facility.[12]

Another example of hydropower supporting economic development and new job creation partnerships is BMW. Access to low-cost and reliable hydropower along with other renewables lured the company to Moses Lake, Washington. Breaking ground on its $200 million manufacturing facility in July 2010, the plant, a joint venture with SGL Automotive Carbon Fibers, was built to supply parts for BMW's line of high performance cars. In fact, the company in 2014 announced it would fund a $100 million expansion of the facility – again citing access to affordable hydropower along with other renewables.[13]

Growth Potential

One of the largest misconceptions of the hydropower industry is that any growth potential is "tapped out". In its new report issued in 2016 titled, Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Resource, the Department of Energy smashes that myth. The Vision analysis finds that U.S. hydropower could grow to nearly **150 GW by 2050**. This would represent close to a **50 percent** increase in capacity.

The report identifies opportunities for **13 GW** of new hydropower capacity by adding generating facilities to existing non-powered dams and canals, upgrades to existing hydropower facilities, and limited development of new stream reaches. It also finds the potential to add up to **36 GW** of new pumped storage capacity.

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[11] Vision Chapter 2, Page 203-204. https://energy.gov/sites/prod/files/2016/10/f33/Hydropower-Vision-Chapter-2-10212016.pdf
[12] http://www.nypa.gov/Press/2013/130322.pdf
[13] http://www.seattletimes.com/business/bmw-plans-big-expansion-of-moses-lake-carbon-fiber-plant/

Looking to the benefits of this potential, the report finds $148 billion in cumulative economic investment. $58 billion in savings in avoided mortality, morbidity and economic damages from air pollution. Cumulative 30 trillion gallons of water withdrawals avoided for the electric power sector. 5,600,000,000 metric tons of CO_2 emissions reductions with $209 billion in avoided global damages. And over 195,000 hydropower-related gross jobs spread across the nation in 2050.[14] Those are quite substantial benefits for our country.

Adding Generation to Non-powered Dams

One of the prime areas of growth in the hydropower industry is on existing infrastructure, such as non-powered dams and conduits. Of the approximately 80,000 dams in the U.S. today only **3 percent** have electric generating facilities. Put another way, **97 percent** of our dams do not produce power and were built for other purposes such as water supply, irrigation, navigation and recreation.

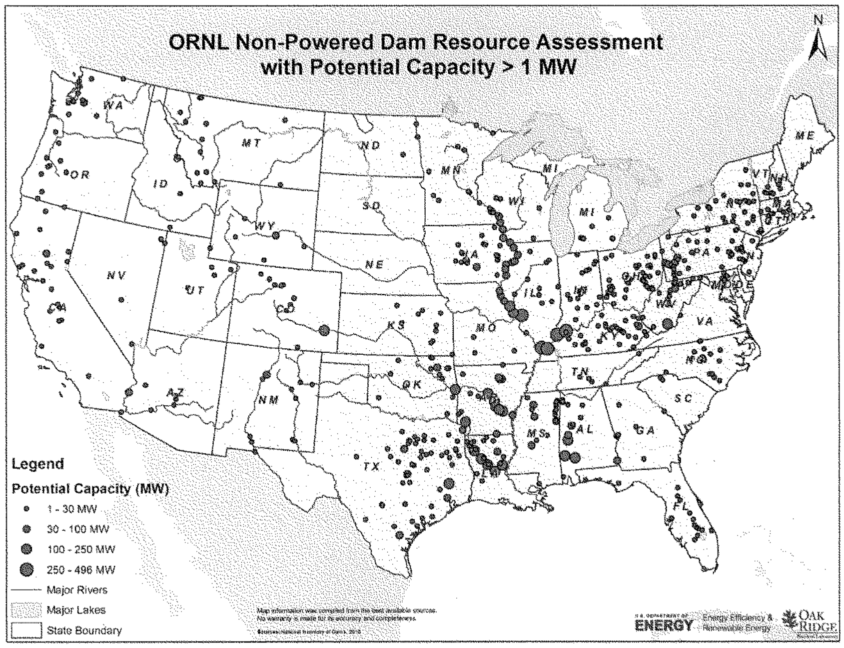
NHA recognizes that not every existing dam may be a suitable candidate to add power generating equipment, as many factors come into play in development decisions: project development costs and revenue opportunities; energy generation potential; natural resource considerations; transmission needs; dam safety; etc. However, what this statistic shows is the large untapped universe of potential opportunities that exist – and that are not being developed in significant part because of the concerns about the uncertain, duplicative and lengthy regulatory process.

Those dams that are candidates for hydropower development are infrastructure that will continue to exist, operate and release flows to meet water supply, irrigation, flood control, and other purposes for which they were originally constructed – regardless of whether hydropower facilities are installed. It is good public policy to take advantage of these existing releases to capture the energy currently untapped at these sites to add to our portfolio of renewable, carbon-free resources.

The U.S. Department of Energy recognized this opportunity and in 2012, through the Oak Ridge National Laboratory, released an assessment of potential capacity at non-powered dams for projects greater than 1MW. The map below on the following page depicts the size and location of the top projects of that survey with capacity greater than 1 MW.[15]

[14] Hydropower Vision, Executive Summary P. 7 and 23.

[15] http://www.energy.gov/eere/water/hydropower-resource-assessment-and-characterization



The results of the study show that over **12 GW** of potential exist across the existing system with **8 GW** of potential available at the top 100 sites.[16] Also of interest, **81 of the top 100** sites were located on federal facilities, in particular, Army Corps of Engineers dams.[17]

These types of projects are some of the lowest impact new developments in the energy sector. No new dams need to be built and the projects aim to utilize existing flows through the projects. This water is already moving through the system, what better way to maximize the benefits of this infrastructure by also generating clean, renewable power with them.

Capacity Additions/Efficiency Improvements at Existing Hydropower Infrastructure

The potential for new conventional hydropower generation is not only about adding new capacity at non-powered dams. Existing hydropower facilities are also expanding through upgrades and efficiency improvements.

[16] 2012 Non-Powered Dams Report, Executive Summary P.VII and VIII.
[17] 2012 Non-Powered Dams Report, Executive Summary P.VIII.

In fact, since EPAct of 2005 and the inclusion of hydropower as an eligible technology in the production tax credit (PTC), over **150 projects** have received certification. These projects have seen, on average, about a **9 percent** gain in generation.[18] These 150 projects represent a small fraction of the hydropower fleet, so there are even further gains to be had if more projects undertake these kinds of upgrades.

And in many instances with these upgrades, the project realizes not only an increase in capacity or generation, but also an increase in environmental performance. The Wanapum Dam Turbine Replacement Project by Grant County Public Utility District in the state of Washington illustrates this. The project includes replacing the original turbines and replacing or refurbishing generating equipment at the dam. The advanced equipment is designed to be 3 percent more efficient. It will also reduce wear on the equipment and improve passage of juvenile salmon.[19]

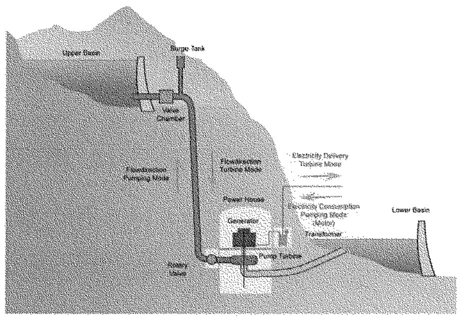
NHA also notes from an infrastructure perspective that there is tremendous opportunity for re-investment in the federal hydropower system. Almost half of the U.S. hydropower generation comes from the federal system, with the bulk owned and operated by the U.S. Army Corps of Engineers, the Bureau of Reclamation and the Tennessee Valley Authority. The median age for federal hydropower projects is 50 years.[20] Turbine and other equipment refurbishments (including repairs, replacements and upgrades) are available and can improve the performance of these projects both from an energy and environmental perspective.

Hydropower Pumped Storage

Pumped storage is a modified use of conventional hydropower technology to store and manage electricity. As shown below, pumped storage projects store potential electricity by circulating water between an upper and lower reservoir.[21]

Electric energy is converted to potential energy and stored in the form of water at an upper elevation. Pumping the water uphill for temporary storage "recharges the water battery" and, during periods of high electricity demand, the stored water is released back through the turbines and converted back to electricity like a conventional hydropower station. See illustration below.

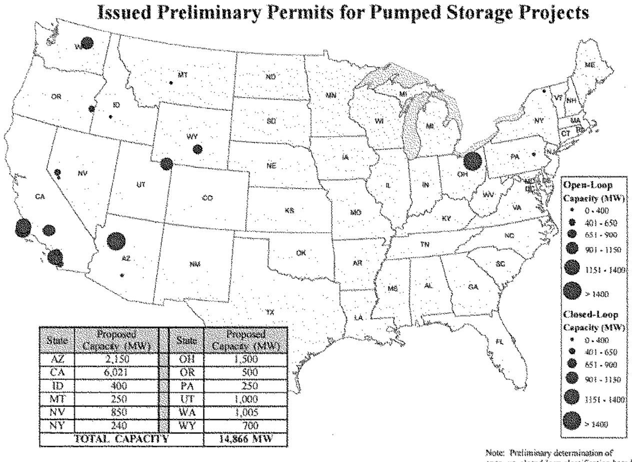
[18] Federal Energy Regulatory Commission data.
[19] http://www.grantpud.org/your-pud/projects/wanapum-dam-turbine-and-generator-replacement-project
[20] Hydropower Vision, Chapter 2, Page 147.
[21] Illustration provided by GE Renewable Energy.



Pumped storage projects able to rapidly shift, store, and reuse energy generated until there is the corresponding system demand and for variable energy integration. This energy shifting can alleviate transmission congestion, which helps more efficiently manage the electric grid, and can reduce the need for costly new transmission projects, as well as to avoid potential interruptions to energy supply.

As more intermittent generation is added to the grid, particularly in the West, the need for the services that pumped storage provides is increasing. As a result, we are seeing a significant renewed interest in these projects, including closed-loop project proposals.[22] As the map below shows, there are currently close to **15,000 MW** of proposed new pumped storage projects before FERC with preliminary permits right now.

Issued Preliminary Permits for Pumped Storage Projects



State	Proposed Capacity (MW)	State	Proposed Capacity (MW)
AZ	2,150	OH	1,500
CA	6,021	OR	500
ID	400	PA	250
MT	250	UT	1,000
NV	850	WA	1,005
NY	240	WY	700
TOTAL CAPACITY			14,866 MW

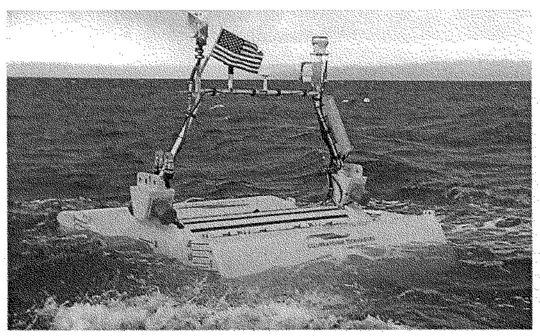
Source: FERC Staff, January 12, 2017

[22] Closed loop pumped storage projects are physically separated from existing river systems. They present minimal to no impact to existing river systems because after the initial filling of the reservoirs, the only additional water requirement is minimal operational make-up water required to offset evaporation or seepage losses.

Again, NHA recognizes that not all of these projects may be developed, however, they clearly rebut the proposition that hydropower is a "tapped out" resource.

Marine Energy and Hydrokinetics

With more than 50 percent of the U.S. population living within 50 miles of coastlines, there is vast potential to provide clean, renewable electricity to communities and cities across the United States using marine and hydrokinetic (MHK) technologies. MHK technologies extract energy from waves, tides, ocean currents, rivers, streams, and ocean thermal gradients. Though still in its early stages of development as a whole, the MHK industry continues to move forward with new technological innovations, test site developments, and demonstration projects.[23] DOE assessments have estimated that the total marine resource potential represents up to 25 percent of projected U.S. electricity generation requirements by 2050.[24]



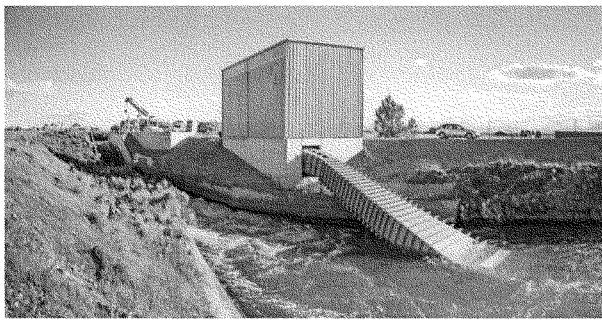
Conduits

Conduit projects utilize existing tunnels, canals, pipelines, aqueducts and other manmade structures that move water. These are fitted with electric generating equipment and are often small projects that are able to extract power from the water without the need for additional infrastructure or a reservoir.

One of the prime opportunities in this sector is at Bureau of Reclamation infrastructure. In a recent study, Reclamation identified 373 potential sites with a capacity of 103 MW, enough to power 33,000 homes.[25]

[23] Photo below of technology demonstration of Columbia Power Technologies of Charlottesville, Virginia
[24] https://energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-characterization
[25] Site Inventory and Hydropower Energy Assessment of Reclamation Owned Conduits (Final Report - March 2012). https://www.usbr.gov/power/CanalReport/

In addition, as a result of the expedited review of non-federal conduit projects under the Hydropower Regulatory Efficiency Act of 2013, the Federal Energy Regulatory Commission (FERC) has approved dozens of small conduit projects across the country.[26][27]



Also, in 2013, legislation was passed focused on similar small conduit development at Bureau of Reclamation infrastructure and Reclamation has made changes to its lease of power privilege (LOPP) program. Reclamation continues to see increased interest in these project opportunities as well.[28]

New Stream-Reach Development

Lastly, the DOE has also recently conducted a study of potential new greenfield projects. The assessment concluded that the technical resource potential is 85 GW of capacity. When federally protected lands—national parks, national wild and scenic rivers, and wilderness areas—are excluded, the potential is about 65 GW of capacity.[29] Not all of these new hydropower opportunities are likely to move forward once site-specific considerations are taken into account. Site selection will be an important factor. Additionally, the industry and the DOE are investigating innovative new technologies and operational regimes to see where some of this potential can be realized, while also minimizing potential impact.

Challenges for Hydropower and Policy Needs

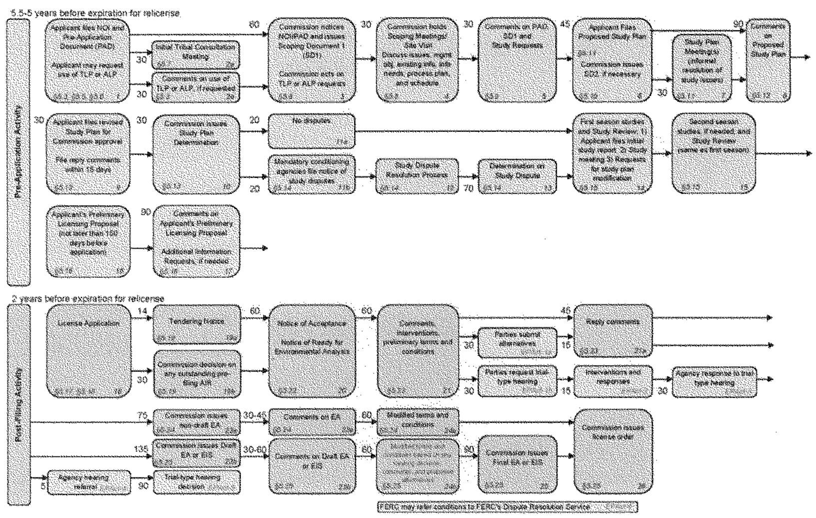
To begin, hydropower has the longest, most complex development timeline (for project relicensing or new project approvals) of any of the renewable energy technologies, with some

[26] https://www.ferc.gov/industries/hydropower/indus-act/efficiency-act/qua-conduit.asp
[27] Picture of Natel Energy, Monroe Hydro Project, a 250 kw hydroelectric plant located in an irrigation canal, in partnership with Apple.
[28] https://www.usbr.gov/power/LOPP/index.html
[29] http://www.energy.gov/eere/water/downloads/new-stream-reach-hydropower-development-fact-sheet

projects taking **<u>10 years or longer</u>** from the start of the licensing process through construction to being placed-in-service.

This process requires a considerable up-front financial commitment from the developer or asset owner to undertake the engineering and environmental studies required for various federal and state approvals. The chart below outlines the integrated licensing process or ILP, the default process, of several, for authorizing hydropower projects.

Integrated Licensing Process
(Section 241 of the Energy Policy Act of 2005)



*Section 241 of the Energy Policy Act of 2005 in pink.

A multitude of federal and state agencies, as well as the public and other stakeholders, play a major and important role in the process. And in the chart above, additional authorizations such as those required by federal dam owners if building on their infrastructure, are not included. These decisions and authorizations have tended to come at the end of the timeline after the FERC issuance of the license.

Water is a public resource and NHA and the industry recognize the necessity for and value of thorough review of project applications. However, redundancies and sequential reviews contained in the overall process are key reasons for delays. For example, for projects adding generating facilities to non-powered federal dams, FERC may issue a license, yet that project cannot commence construction until it has received additional approvals from the federal owner of the dam (Corps of Engineers or Bureau of Reclamation). If there are unanticipated delays for those additional needed approvals, no work can commence. It is a similar case for state issuances of Clean Water Act Section 401 water quality certifications. A license cannot be issued, nor work commenced, until the certificate is approved.

NHA believes the time, cost and risks associated with licensing hydropower projects are not commensurate with the impacts, particularly when compared with other forms of generation – conventional or renewable. As former NHA President John Suloway testified before Congress in 2015[30], because of this, when faced with the choice of what type of generation to install, there is less risk in choosing a simple cycle turbine or a combined cycle plant that burns natural gas or low-sulfur oil, than building a hydropower plant.

While there is some variability with regard to size and location, the regulatory approval processes for simple cycle turbine or combined cycle plants are generally 1-2 years – even in urban areas like New York City. The FERC licensing process for hydro plants is generally 8 years or more, including both licensing and pre-filing activities. With regard to licensing costs, a combined cycle plant is approximately $1 to $2 million; whereas, some studies alone can cost multiples of that figure for a hydropower project. It is not uncommon for a hydropower license applicant to spend $10 million or more on just the licensing process.

And this is not just an issue for new project deployment, but also for existing projects that are undergoing relicensing. In fact, by 2030, **approximately 400 projects**, representing **18,000 MW** of capacity, will be in or have gone through relicensing. NHA has already begun to hear from owners of smaller projects, particularly in the Northeast, but across the country, that the process costs for licensing may render projects uneconomic and result in the surrender of licenses. As states continue to press for more clean and renewable energy resources, it would be unfortunate to lose the many benefits these existing hydropower projects provide.

NHA believes that Congress and the Administration should seek to reduce uncertainties in the hydropower licensing and relicensing processes, eliminate unnecessary and/or duplicative studies or other requirements, create discipline in the schedule, and reduce the time for obtaining federal and state approvals. In doing so, policymakers would be recognizing the value of hydropower as a critical component in the nation's energy supply portfolio. In addition, NHA believes process improvements can maintain the substantive ability of federal and state regulators to appropriately protect, mitigate and enhance natural resources.

Another issue that holds back hydropower is its limited recognition, or the complete lack thereof, as a renewable and/or clean energy resource under federal or state programs/environmental markets. State renewable portfolio standards provide one good example, and often contain restrictions on the amount of hydropower that is eligible. These include: project capacity limitations (30 MWs or less); placed-in-service restrictions (no eligibility for existing generation); resource and technology limitations (i.e. existing infrastructure; no new dams; capacity uprates or efficiency improvements only); explicit operational or impact criteria (run-of-river; low-impact certified), among others.

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[30] https://energycommerce.house.gov/hearings-and-votes/hearings/discussion-drafts-addressing-hydropower-regulatory-modernization-and

On the federal side, there are many recent examples of initiatives related to renewable energy development on public lands, federal renewable energy procurement policies, and government-wide sustainability goals that either excluded hydropower as an eligible renewable technology, or qualified hydropower in a way that significantly reduces (or effectively eliminates) its ability to participate.

For example, in 2015, Executive Order No. 13,693 utilized a definition of "renewable electric energy" that includes only new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project and yet excludes generation added to non-powered dams and others.[31] Another example is the 2012 U.S. Army Corps of Engineers proposal for "Large Scale Renewable Energy Production for Federal Installations", which completely excluded hydropower as an eligible resource. And also, the EPA's Green Power Partnership Program significantly limits the definition of qualifying hydropower. When hydropower is not included and recognized as a renewable resource on par with other resources like wind and solar, it creates a distinct economic and market disadvantage for the industry participants (existing asset owners and developers alike).

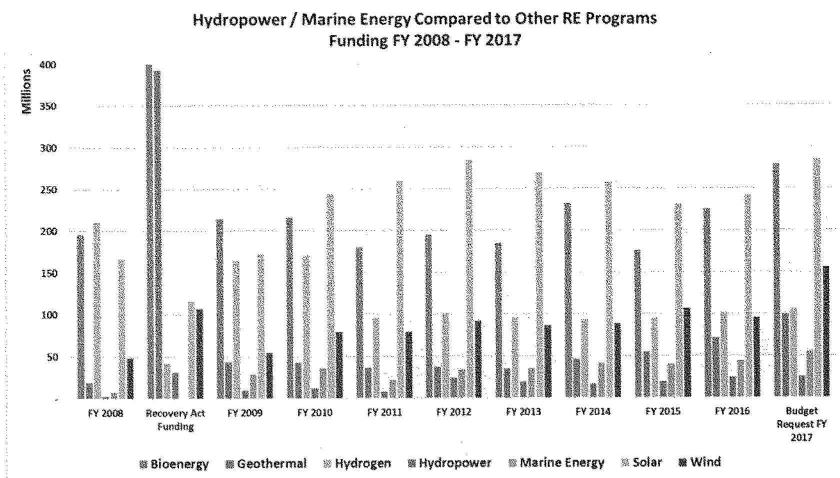
This disadvantage is no more clearly illustrated than in the context of the extension of the renewable energy tax incentives (Section 45 production tax credit (PTC) and Section 48 investment tax credit (ITC)). The PATH Act of 2015 created a competitive imbalance between incentives for wind and solar and other renewables, including hydropower. While the PTC and ITC for hydropower, MHK, and other technologies was extended through the end of 2016 (now lapsed), the credits for electricity produced from wind and solar facilities was extended for years longer. This on top of the fact that the hydropower industry, only receives, and has only ever received, half-credit under the PTC since becoming eligible years after the program was created for the wind industry.

As hydropower projects continue to compete for investment dollars, the policies adopted at the end of 2015 tipped the scales against investment in hydropower, putting the industry at a distinct disadvantage – a disadvantage that is magnified when you include the RPS policy treatment other renewable resources have as described above. NHA is working to fix this inequity to allow hydropower resources to better compete in the marketplace without the thumb on the scale tipped in favor of other renewable resources in the tax arena.

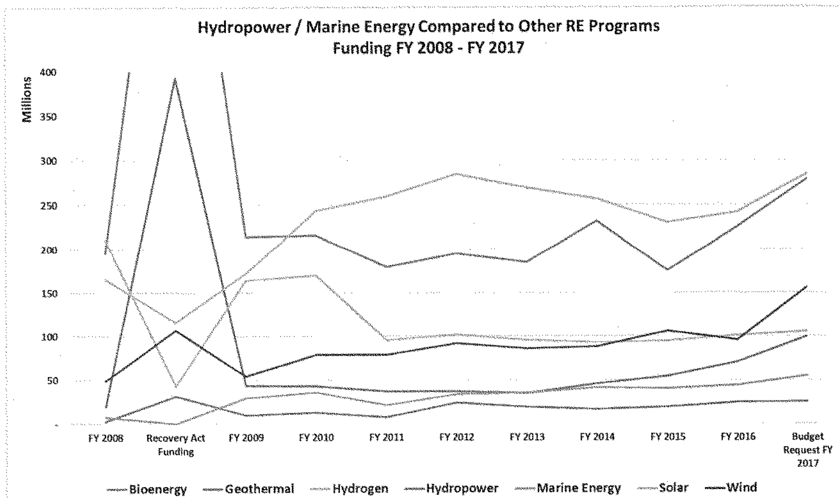
Lastly, on the federal policy front, NHA highlights investment in R&D for technology innovation. The DOE Water Power program, which represents the single largest source of renewable electricity in the United States today, still remains one of the smallest of the Office of Energy Efficiency and Renewable Energy (EERE), particularly when compared to the funding levels for other EERE programs.

The graph that follows charts the funding levels for the EERE programs from FY 2008 through the Administration's FY 2017 funding request, including American Recovery and Reinvestment Act of 2009 (ARRA).

[31] Fixing America's Surface Transportation Act (Pub. L. No. 114-94) Executive Order No. 13,693, Planning for Federal Sustainability in the Next Decade (2015)



The next graph below presents the same information, but more clearly shows the trend lines through time for each individual renewable energy technology program.



NHA appreciates and is encouraged by the growing investments by Congress in the DOE's Water Power program activities in recent years. However, as these charts clearly indicate, the level is still substantially below that afforded other EERE programs, with the hydropower program receiving the least funding, followed by the MHK program receiving the next lowest level of funding. One of the factors for the tremendous growth in other renewables over the last several years is the sustained investment shown by the federal government in technology R&D and market acceleration initiatives in these sectors.

One final policy area that NHA would like to raise is that of regional electricity/power markets. Similar to what was discussed above on the state and federal energy policy front, oftentimes the various grid benefits both hydropower and pumped storage projects provide are not valued or compensated in our existing electricity markets. NHA, in 2015, filed comments with FERC on this issue that we believe are useful in this discussion and highlight the need to re-examine policies in order to promote hydropower deployment.[32]

In its filing, NHA notes:

> "While energy storage projects are eligible to participate in some markets, there are several attributes of energy storage and specifically pumped storage units that are not currently addressed by these tariffs. Pumped-storage plants can offer significantly more benefits to the electric system than those commonly recognized by ISOs and included in the comments previously received by the ISO commenters. Specifically pumped storage plants can offer real time system inertia [see FERC 755 reference to flywheel effect], generator droop setting that can respond to system conditions instantaneously, and Automatic Voltage Regulation Control (AVR) that can adjust rotor field strength in real time. All three of these services can be provided by traditional hydropower generators as well and pumped storage plants. These three services are critical services that allow instantaneous response to grid conditions that keep the voltage and frequency stable as other services like AGC respond in the ultrafast 1-4 second time frame. Markets are not currently available to compensate for these services.
>
> Additionally, energy storage devices are able to provide grid services that offset the need for new transmission and or distribution infrastructure. Under the current regulatory environment, energy storage plants are classified as a generation resource and are not currently eligible for to get a transmission rate of return for these services."

Conclusion

Both the existing system and new hydropower projects have a critical role to play in meeting our nation's energy, environment, and economic development objectives and much is at stake for hydropower and the families, businesses and communities that rely on its low-cost, reliable, renewable generation.

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[32] See: Electric Storage Participation in Regions with Organized Wholesale Electric Markets, FERC Docket No. AD16-20-000

NHA and the hydropower industry stand ready to help meet our common clean energy goals and we look forward to working further with Congress and the Administration to find pathways to address the important policy issues – federal, regional and state – to fully maximize and unlock the potential of the hydropower resource.

As the Congress works to address our energy and infrastructure needs, whether that be on a new national infrastructure program or further work on an energy bill, policies that support the preservation of the existing hydropower system and promote the deployment of new projects (for all categories of water power technologies) must be included. A greater recognition that our hydropower infrastructure is incredibly valuable is needed, and continued investment and re-investment in the system is critical to our energy future and national security.

I thank the Committee for providing me this opportunity to testify and I look forward to answering your questions.

Mr. UPTON. Thank you.

Mr. Mansour—Christopher Mansour, VP, Federal affairs, for Solar Energy Industries Association.

Welcome. You need to hit that button.

STATEMENT OF CHRISTOPHER MANSOUR

Mr. MANSOUR. There we go. And members of the committee, I am Christopher Mansour, vice president for Federal affairs at the Solar Energy Industries Association. Thank you for inviting me to appear here before you today.

Before I begin, just let me say that our president and CEO, Abby Hopper, regrets being unable to attend the committee today. She's at the U.S. International Trade Commission that's right now having its remedy hearing for the solar trade case. Further information on this trade case and the threat it poses to our industry is available in my written testimony.

I am testifying today on behalf of SEIA's almost 1,000 member companies and the 260,000 Americans employed in the U.S. solar industry. Solar is a strong driver for the American economy.

In fact, one out of every 15 new jobs created in the United States in 2016 was a solar job. While California leads the way in solar jobs, States like Nevada, Florida, Arizona, Texas, and North Carolina each employ over 7,000 solar workers.

2016 was also a record year for solar deployment in the country. We added 15 gigawatts of solar capacity, double the amount installed in 2015. Solar capacity in the United States now exceeds 47 gigawatts. Solar firms invested nearly $23 billion in the United States in 2016.

Solar was also the number-one source of new generating capacity in the United States in the last year. In the first quarter of 2016, our country hit an important milestone of installing solar panels on 1 million American homes.

Our industry will double that number to 2 million by 2018 and double it again to 4 million homes by the end of 2022.

Solar is a growing part of our electricity mix, delivering 1.4 percent of the Nation's total electrical usage. This is expected to grow to 4 percent by 2020.

Solar has been and will continue to be deployed in a manner that adds to the viability and security of the grid.

Regarding the Department of Energy's recent staff study on grid reliability, we appreciate the willingness of the secretary and his team—Secretary of Energy, Mr. Perry, and his team—to listen to our concerns with and our suggestions for the report.

We believe that many of comments were reflected in the final product. In particular, we agree with one of the findings in the report that stated, quote, "While concerns exist about the impact of widespread deployment of renewable energy on the retirement of coal and nuclear power plants, the data do not suggest a correlation," closed quote.

Last week, the secretary sent the FERC a proposed rule to address grid resiliency through cost-based payment mechanisms for certain coal and nuclear power plants.

The secretary cites the need to, quote, "protect American people from the threat of energy outages that could result in the loss of traditional base load capacity,“ and specifically identifies the ability to provide voltage support, frequency services, operating reserves, and reactive powers benefits that such generation resources bring to the grid.

SEIA agrees with the secretary that FERC should continue its important work on price formation. We also agree with the assertion that generators—all generators—should be fully compensated for the energy, capacity, and ancillary services that they provide to the grid.

Where we do not agree with the secretary is that this rushed rulemaking is the right way to achieve those ends. FERC can and should define any reliability services or products that are missing from the marketplace in a technology-neutral manner.

Healthy competition will yield the most innovative solutions at the lowest prices for consumers while protecting ratepayers from having to shoulder unreasonable and unnecessary additional costs for little benefit.

In my written testimony, you'll find evidence of solar's contributions to grid reliability under both normal operating conditions and during unusual events.

During the recent solar eclipse, grid operators accurately predicted diminished solar output and adjusted generation sources accordingly with no subsequent blackouts or brownouts.

Solar also withstood the past month's multiple hurricanes. Based on what our member companies have told us, very few panels—solar panels were actually damaged during these storms.

Moreover, studies by NREL and others cited in my written testimony consistently demonstrate that not only can our regional grids accommodate high penetration of solar and other renewable sources but that solar projects have the ability to provide important services to the grid such as regulation, voltage support, and frequency response during various operating modes.

In closing, we support Federal energy policies that promote reliability, security, and fuel diversity. Increased investments in transmission will bring greater reliability and access to more diverse sources of generation.

We look to FERC to ensure that well-functioning wholesale electric—electricity markets thrive. In parts of the country without RTOs and ISOs, FERC must guarantee open access and nondiscriminatory treatment for independent renewable generators.

Finally, incentivizing significant investments in energy storage deployment on the transmission and distribution grids will increase grid reliability and promote another important resource to systems' operators.

Thank you, and I look forward to your questions. Thank you, Mr. Chairman.

[The prepared statement of Mr. Mansour follows:]

TESTIMONY OF

CHRISTOPHER MANSOUR
VICE PRESIDENT, FEDERAL AFFAIRS
SOLAR ENERGY INDUSTRIES ASSOCIATION

BEFORE THE

HOUSE SUBCOMMITTEE ON ENERGY

HEARING ON

Powering America: Defining Reliability in a Transforming Electricity Industry

OCTOBER 3, 2017

Solar Energy Industries Association
600 14th Street NW, Suite 400
Washington, DC 20005
(202) 682-0556
www.seia.org

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee,

Thank you for the opportunity to provide testimony on solar and its contributions to grid reliability. I am Christopher Mansour and I serve as the Vice President of Federal Affairs for the Solar Energy Industries Association (SEIA). I am testifying on behalf of SEIA's 1,000 member companies and the 260,000 American citizens employed by the solar industry. SEIA represents the entire solar industry, encompassing all major solar technologies (photovoltaics, concentrating solar power and solar water heating[1]) and all points in the value chain, including financiers, project developers, component manufacturers and solar installers. Before I begin my testimony, let me thank Chairman Upton and Ranking Member Rush for their leadership and support of solar energy. We are grateful that the Committee recognizes the increasingly important contributions solar makes to our energy supply and the economy, for the benefit of the nation.

I. Introduction

The Solar Energy Industries Association is celebrating its 43rd year as the national trade association of the U.S. solar energy industry, having been established in 1974. Through advocacy and education, SEIA and its 1,000 member companies are building a strong solar industry to power America. As the voice of the industry, SEIA works to make solar a mainstream, significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

Our nation is graced with some of the world's best solar resources, in both the quality and quantity of the sunlight we receive as well as the proximity of our best solar areas to some of the country's largest cities and industries. Our exceptionally rich solar resources have much to offer the nation, its economy, and its environment. Solar can contribute substantially to a clean, sustainable domestic energy supply to power growth and prosperity for many decades to come. Stable, long-term policies, including tax, trade, and energy policies are the keystones to realizing solar's ability to deliver reliable, low-cost power to the nation. We are pleased to have this opportunity to address them and other factors needed to maintain the U.S. as a worldwide solar leader.

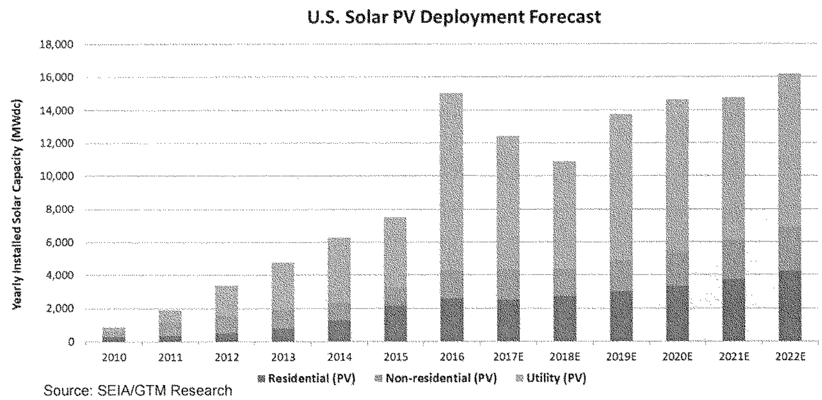
II. The U.S. Solar Industry: Recent Highlights and Future Prospects

Photovoltaic technology was invented in the U.S.A., developed as a marketable energy source

[1] For more information on each of these solar technologies, please see SEIA, "Solar Technologies," *available at* https://www.seia.org/initiative-topics/trade-tech-environment.

in the U.S.A., and last year, solar was the largest single source of electric generating capacity added in the U.S.A.

In recent years, America's solar industry has come a long way in converting its solar resources to the electrical energy our economy needs to thrive. Solar energy is a young industry, but it is growing fast. Solar capacity in the U.S. now exceeds 47 GW, enough to power 9.1 million homes.[2] The following graph illustrates solar's remarkable growth since 2010, including expected installations for the next five years:



Source: SEIA/GTM Research
U.S. Solar Market Insight

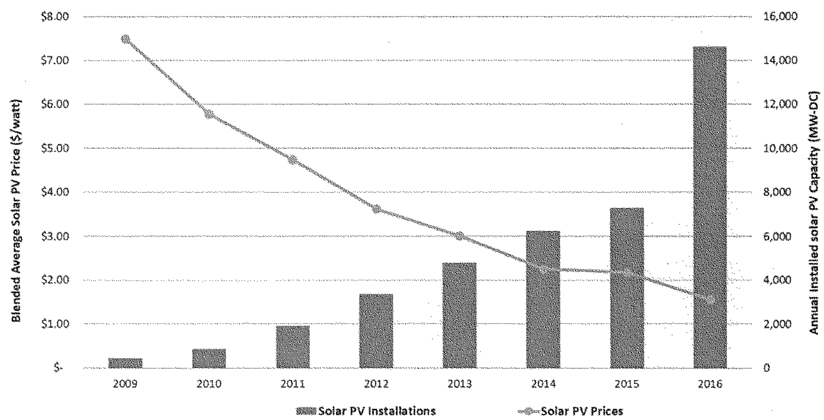
This phenomenal growth is the result of private investment, technological innovation, a maturing industry and smart federal and state policies. The federal government has received a strong return on its investment of public dollars, with benefits to our economy that far exceed their costs.

Despite solar's spectacular growth over the last decade, it still makes up only 1.4% of the nation's total electricity mix. By 2020 solar is expected to represent close to 4% of total electricity generated.
Although solar is growing quickly, the nation has just begun to tap into its solar resources. Solar's potential to serve the nation is far greater than its remarkable success to date. Solar power transforms the endless, free energy we receive from the sun into electric power to drive

[2] SEIA and GTM Research, "U.S. Solar Market Insight" report, *available at* https://www.seia.org/us-solar-market-insight.

commerce, industry and our way of life, at decreasing costs. Our nation can – and should – depend on its exceptional solar resources to power its exceptional future.

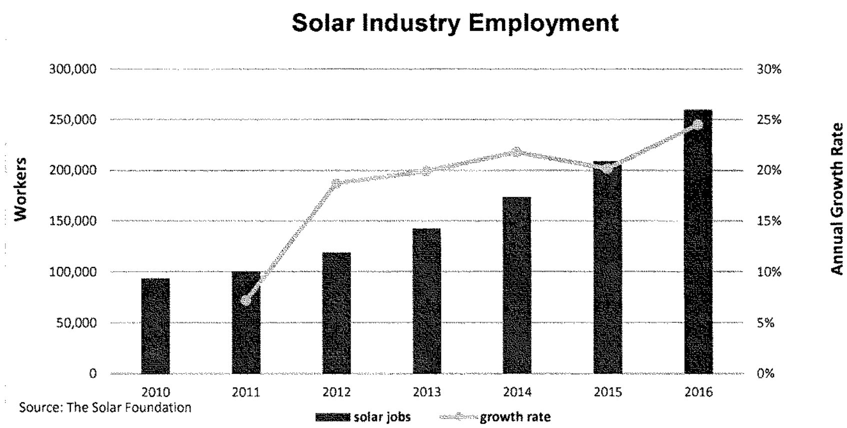
As solar provides increasing amounts of energy to the country, its costs are decreasing dramatically. As shown in the chart below, PV system prices are decreasing in every market segment, year-over-year.[3] Solar deployment is paying great dividends to the American economy and continues to act as catalyst to drive down future costs.



In addition, the 9,000 American solar companies employ more than 260,000 American workers and invest tens of billions of dollars every year into the American economy. In 2016, solar industry employment grew 25% over 2015 to reach over 260,000 workers, according to the Solar Foundation.[4]

[3] Data provided by SEIA and GTM Research.

[4] The Solar Foundation, "National Solar Jobs Census 2016," *available at* https://www.thesolarfoundation.org/national/.



Last year, the solar industry was responsible for one out of every fifty new jobs created in the U.S. These are jobs in fields ranging from contracting and engineering to manufacturing, R&D, and finance, with median wages topping $25/hour. While California leads the way in solar jobs, states like Nevada, Florida, Arizona, Texas and North Carolina each employ more than 7,000 solar workers.[5] In 2016, the Department of Energy reported that the U.S. solar industry employed more workers than the natural gas industry and more than twice as many workers as the coal industry. In fact, solar represented 18% of all U.S. energy jobs, second only to the oil industry.[6]

In addition, the solar industry has pumped more than $111 billion into the U.S. economy since 2000, with nearly $23 billion invested in 2016 alone. By 2021, the solar energy industry will invest another $86 billion in communities across the U.S. These investments not only put Americans to work, but represent millions of dollars in new tax revenue for state and local governments.

III. Solar is a Reliable Resource and Contributes to Grid Reliability

Recently, the value to the national electric grid of solar and other renewable energy sources has been questioned. As can be seen from the numerous studies referenced in this testimony, solar

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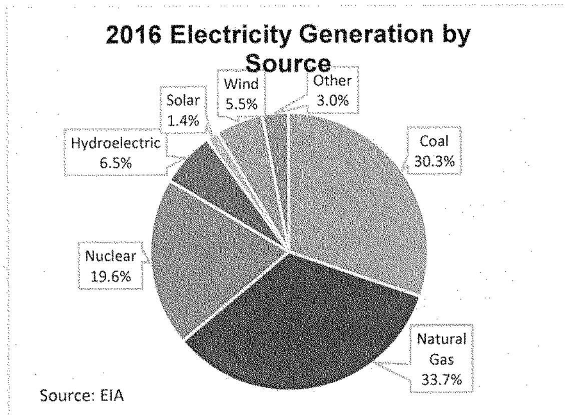
[5] *Ibid.*

[6] U.S. Department of Energy, "U.S. Energy and Employment Report," January 2017. *Available at* https://energy.gov/downloads/2017-us-energy-and-employment-report.

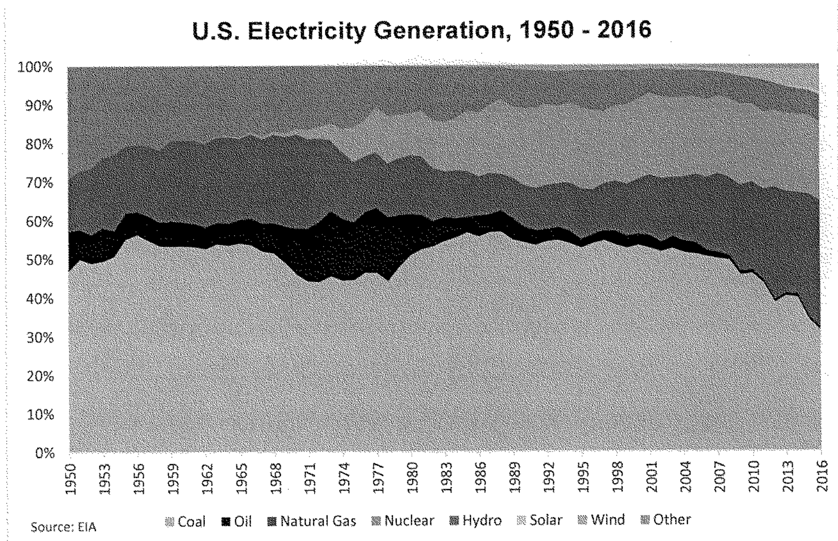
and renewables provide significant benefits to the grid in terms of reliability, fuel diversity, and security.



The U.S. electric grid has never had a more diverse array of generating resources (see chart above). According to the Energy Information Administration (EIA), in 2016 34% of U.S. electric generation came from natural gas, 30% from coal, 20% from nuclear, 9% from non-hydro renewables and 7% from other sources.[7] 2015 marked the first year ever in which 7 distinct technologies generated at least 0.5% of the nation's electricity. Similarly, grid operator PJM recently calculated that 2016 featured the most diverse electricity mix in the nation's history using a Shannon-Wiener index.[8] (not pictured)

[7] U.S. Energy Information Administration data, *available at* https://www.eia.gov/electricity/data.php

[8] PJM Interconnection, "Appendix to PJM's Evolving Resource Mix and System Reliability," March 30, 2017, page 1. *Available at* http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-appendix-to-pjms-evolving-resource-mix-and-system-reliability.ashx.



In addition to providing fuel diversity, multiple studies from the Department of Energy's National Renewable Energy Laboratory (NREL) have shown that the existing grid can handle high penetrations of renewable energy without compromising reliability and performance. In both its Western Wind and Solar Integration Study and Eastern Renewable Generation Integration Study, NREL finds that the existing western and eastern electric grids can accommodate upwards of 30% of solar and wind power without requiring extensive infrastructure investments.[9] An additional study from NREL finds that "renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050."[10]

Additional study of the Western grid led to NREL's finding that any maintenance costs created by a need to cycle fossil-fuel plants to accommodate wind and solar generation are more than

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[9] NREL, Western Wind and Solar Integration Study (2010), *available at* http://www.nrel.gov/docs/fy10osti/47434.pdf and NREL, Eastern Renewable Generation Integration Study (2016), *available at* http://www.nrel.gov/docs/fy16osti/64472.pdf.

[10] NREL, Renewable Electricity Futures Study (2012), *available at* https://www.nrel.gov/analysis/re-futures.html.

offset by the fuel savings associated with those resources.[11] Phase three of the same study demonstrated that reliability of the western grid can be maintained at high renewable penetration rates in the face of large system disturbance (such as the loss of a fossil plant).[12]

Grid operators across the country have found that reliability on the grid can be maintained at higher penetrations of renewables. The California Independent System Operator (CAISO), which manages the most solar resources in the country, finds that the state will have no issues in maintaining reliability while hitting its 33% renewables target by 2020.[13] PJM, which operates much of the eastern grid in the U.S., found in a 2014 study that it would not encounter reliability issues with 30% of their energy coming from solar and wind.[14]

Solar is Reliable Alone and Paired with Other Resources

In a joint study conducted by NREL, CAISO, and First Solar, researchers found that solar photovoltaic power plants – equipped with commercially available inverter technology – can offer "electric reliability services similar, or in some cases superior to, conventional power plants."[15] Specifically, the solar power plant can provide regulation, voltage support and frequency response during various operation modes. The tables below show the PV plant's ability to accurately respond to CAISO energy management signals, compared to other generation sources. Likewise, Concentrating Solar Power plants (CSP), which produce electricity by using the sun to heat boilers and spin turbines, are easily paired with thermal energy storage and provide a host of grid benefits that allow them to function like any fossil fuel plant.

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[11] NREL, Western Wind and Solar Integration Study, Phase 2 (2013), *available at* http://www.nrel.gov/docs/fy13osti/55588.pdf.

[12] NREL, Western Wind and Solar Integration Study, Phase 3 (2014), *available at* http://www.nrel.gov/docs/fy15osti/62906.pdf.

[13] California Public Utilities Commission, Beyond 33% Renewables: Grid Integration Policy for a Low-Carbon Future (2015), *available at* http://www.cpuc.ca.gov/General.aspx?id=8982.

[14] General Electric International, Inc., PJM Renewable Integration Study (2014), *available at* http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx.

[15] NREL, Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant (2017) *available at* http://www.nrel.gov/docs/fy17osti/67799.pdf.

Table 2. Measured Regulation Accuracy by 300-MW PV Plant

Time Frame	Measured Accuracy of Solar PV Plant
Sunrise	93.7%
Middle of the day	87.1%
Sunset	87.4%

Table 3. Typical Regulation-Up Accuracy of CAISO Conventional Generation

	Combined Cycle	Gas Turbine	Hydro	Limited Energy Battery Resource	Pump Storage Turbine	Steam Turbine
Regulation-Up Accuracy	46.88%	63.08%	46.67%	61.35%	45.31%	40%

In combination with battery storage, solar has proven to be an easily dispatchable asset at times in which the grid fails. Programs like the SunSmart Emergency Shelter program in Florida have added solar and storage solutions to hundreds of schools and emergency shelters, offsetting everyday electricity costs and establishing a reliable source of electricity in the event of a grid failure.

Solar's ability to be used as a distributed resource has important implications for grid security. With smarter grid technology and advanced power electronics, grid operators can reallocate electrons from individual rooftop systems to where they are most needed in the face of disturbances to other generating units. Distributed systems can be paired with storage and turned into resilient microgrids. According to former CIA director James Woolsey, such microgrids could prevent "a single failure from cascading into a catastrophe."[16]

One of the biggest users of renewable energy in the U.S. is the military, which values solar for its portability and dispatchability. Solar use on the battlefield and at sea reduces to need for sometimes dangerous and costly fuel resupplies, while solar at a military base reduces electricity costs and, when paired with storage, creates a resilient energy environment in the form of a micro-grid.

[16] Woolsey, R. James, Rachel Kleinfeld, and Chelsea Sexton, "No Strings Attached: The Case for a Distributed Grid and a Low-Oil Future," *World Affairs Journal*, September/October 2010. *Available at* http://www.worldaffairsjournal.org/article/no-strings-attached-case-distributed-grid-and-low-oil-future.

Southern California Fire Caused Nearly 1,200 MW of Solar to Trip Offline

In August 2016, a wildfire around in Southern California caused several transmission lines to fault, which in turn caused a loss of PV output. The largest disruption of the day caused solar generators' inverters to trip and cease delivering electricity to the grid. When the solar inverters tripped, approximately 1,200 megawatts of electricity were lost. A joint task force comprised of NERC and the Western Electricity Coordinating Council (WECC) investigated the incident issued a report[17] earlier this year.

The investigation found that the loss of generation was due to the inverters perceiving a low-frequency condition and low-voltage blocking of the inverters. In response to either condition, the inverters are programmed to "trip," cease delivering electricity to the grid, and resume delivering electricity five minutes later. As designed, the NERC-WECC report found that "approximately 66 percent of the generation lost recovered within about five minutes."[18]

The solar energy industry and utilities worked with inverter manufacturers to make modifications to ensure that these resources have sufficient "ride-through" capability during low system frequency conditions. In addition, IEEE Standard 1547, which applies to inverters connecting to the distribution system, is currently under revision. Changes are expected to prevent similar voltage and frequency issues for solar on the distribution grid.[19] The NERC-WECC report also recommends reviewing NERC Reliability Standard PRC-024-2, a standard that details voltage and frequency relay settings for generation connected to the bulk electric system, to better consider inverter behavior.

Evolution of standards and operating procedures is not unusual when increasing use of new technologies. For example, when wind technology was believed to be subject to voltage irregularity, manufacturers developed new-generation turbines that possessed low-voltage ride-through capability. The DOE Grid Study notes that "manufacturers have designed electronic controls for newer model wind turbines that can provide automatic generation

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[17] North American Electric Reliability Corporation (NERC), "1,200 MW Fault-Induced Solar Photovoltaic Resource Interruption Disturbance Report," (June 8, 2017); See, http://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf

[18] *Ibid,* p. 2

[19] Institute of Electrical and Electronics Engineers (IEEE), "IEEE P1547 Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces (full revision of IEEE Std 1547);" See, http://grouper.ieee.org/groups/scc21/1547_revision/1547revision_index.html

control, primary frequency response and synthetic inertia" (page 73). Reviewing and improving inverter standards is consistent with one of the DOE Grid Study policy recommendations:

> **"Promote Research and Development (R&D) of next-generation/21st century grid reliability and resilience tools:** DOE should focus R&D efforts to enhance utility, grid operator, and consumer efforts to enhance system reliability and resilience ...
>
> - Focus R&D on improving VRE integration through grid modernization technologies that can increase grid operational flexibility and reliability through a variety of innovations in sensors and controls, storage technology, grid integration, and advanced power electronics. The Grid Modernization Initiative should also consider additional applications of high-performance computing for grid modeling to advance grid resilience." P. 126

<u>The August 21, 2017 Solar Eclipse Caused No Reliability Issues</u>

On Monday, August 21, 2017, a total solar eclipse passed over the continental United States, affecting solar output. Researchers at the Electric Power Research Institute (EPRI) spent the day monitoring solar energy production across the country, culminating in a recently-released report.[20] The reliability lessons learned from the eclipse were not surprising: solar PV systems with 99% or less eclipse coverage remained connected to the grid, with only two monitored PV systems shutting down for a few minutes during the event.

The impact of the eclipse on California grid reliability was the most instructive because California has six times more solar electric capacity than any other state. There, the eclipse took 3,000 megawatts of utility-scale and rooftop solar off the grid.[21] Grid operators had to deal with two solar ramp-ups, instead of just one. According to *RTO Insider, the* "CAISO had to manage not only the rapid loss of solar but also a steeper-than-usual climb of that resource compared with a normal day as the sun returned. CAISO predicted it would lose about 51 MW/minute, and as the blockage waned, solar generation came back at a rate of 93 to 100 MW/minute. On a normal morning, solar ramps about 29 MW/minute."[22]

To maintain grid reliability, the CAISO ramped up hydro and natural gas generation as solar dropped off, then did the reverse as solar generation returned. CAISO, typically a net exporter,

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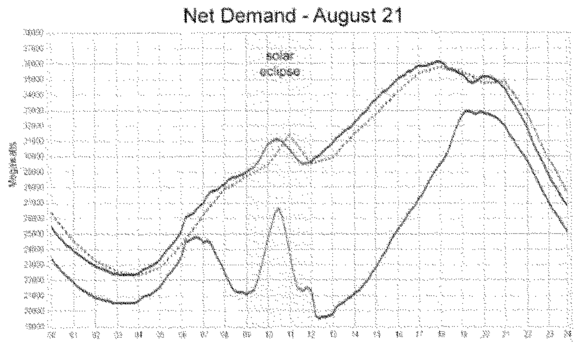
[20] Electric Power Research Institute, "Solar Siesta: Photovoltaic Generation and the Great American Eclipse," (September 4, 2017); See, https://www.epri.com/#/pages/product/000000003002011693/.

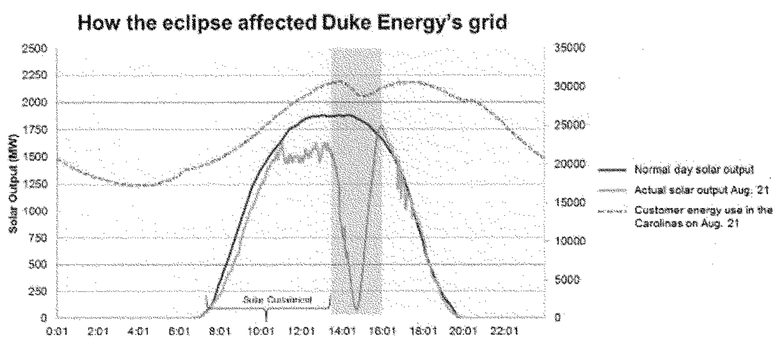
[21] CAISO, "Managing the Eclipse," (August 21, 2017); See, http://www.caiso.com/informed/Pages/SolarEclipse/Default.aspx.

[22] Jason Fordney, Tom Kleckner, Amanda Durish Cook, Rory D. Sweeney and Michael Kuser (RTO Insider), "Grid Operators Manage Solar Eclipse," (August 21, 2017); See, https://www.rtoinsider.com/rtos-solar-eclipse-grid-operators-48180/.

also used power from the Energy Imbalance Market, a wholesale market made up of utilities in several states that allows entities to buy and sell power within the hour it's needed.



In North Carolina, which is currently second in the nation for installed solar capacity, the eclipse took place in the early afternoon, normally a peak time for solar energy production. Duke Energy lost about 1,700 of its 2,500 MW solar capacity during the eclipse, but other resources like natural gas plants were used to fill the void.[23]



In short, grid operators across the country reported no major reliability issues, even as solar output dipped on the day of the eclipse. Grid operators' ability to accurately forecast solar

[23] Jessica Wells (Illumination/Duke Energy), "What happened to solar energy during the eclipse?," August 23, 2017. *Available at* https://illumination.duke-energy.com/articles/what-happened-to-solar-energy-during-the-eclipse.

production led this rare astronomical event to be a non-event for grid reliability.

DOE's Proposed "Grid Resiliency Rule"

Last week the Secretary of Energy sent to the Federal Energy Regulatory Commission (FERC) a proposed rule to address grid resiliency through cost-based payment mechanisms for coal and nuclear power plants that are (a) physically located within the boundaries of a Regional Transmission Organization (RTO) or Independent System Operator (ISO) and (b) have at least a 90-day fuel supply onsite.[24] The Secretary cites a need to "protect the American people from the threat of energy outages that could result from the loss of traditional baseload capacity"[25] and specifically identifies "the ability to provide voltage support, frequency services, operating reserves, and reactive power" as benefits that such generation resources bring to the grid.

SEIA supports the overarching theme of the Secretary's letter: FERC should continue its important work on price formation. We also agree with the assertion that generators – all generators – should be fully compensated for the energy, capacity, and ancillary services they provide to the grid. However, this rushed rulemaking is not the right way to achieve these ends. FERC can and should define any reliability services or products that are missing from the marketplace in a technologically-neutral manner. In competitive markets, such as those operated by RTOs and ISO, sellers should provide and price those services according to buyers' willingness to procure those products. Healthy competition will yield the most innovative solutions at the lowest prices to consumers.

IV. Solar is a Low-Cost Option Around the Country

Solar is an energy source available in every U.S. Congressional district. Because most of the cost of a solar installation is up front and no additional fuel cost is needed to operate, solar plays a key role in hedging against rising fossil fuel prices. Building on earlier research, NREL found in a 2013 study that adding solar and wind to an electricity resource portfolio at penetration rates up to 40% significantly reduces exposure to variability in fossil fuel costs.[26]

According to Lazard, a leading financial advisory and asset management firm, while the Levelized Cost of Electricity (LCOE) for generation from new coal plants has remained around

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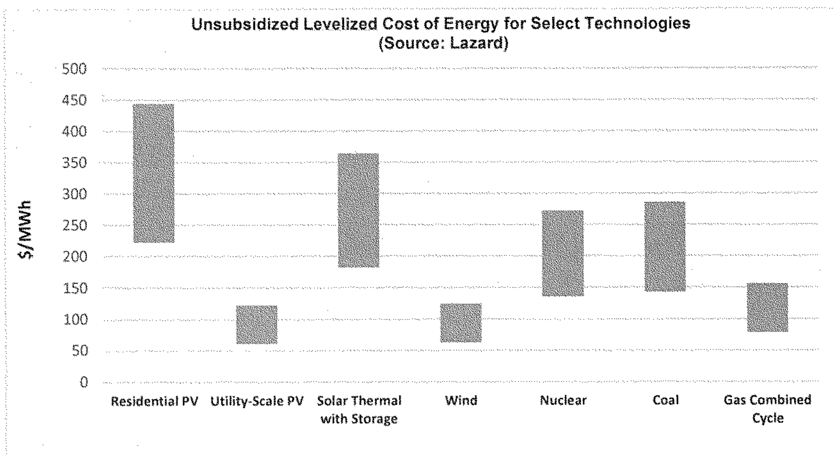
[24] See letter filed in Docket No. RM18-1-000, available at https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14696057 (Sept. 28, 2017).

[25] *Ibid*, p. 1.

[26] NREL, The Use of Solar and Wind as a Physical Hedge against Price Variability within a Generation Portfolio, (2013), *available at* http://www.nrel.gov/docs/fy13osti/59065.pdf.

$100/MWh over the past 5 years, the LCOE for electricity from natural gas plants has dropped from $75/MWh to $63/MWh. Lazard finds the unsubsidized levelized cost of utility-scale solar now ranges from $46 to $92/MWh, on par with wholesale electricity from new wind and natural gas plants. Residential solar, which competes against retail electricity prices, is now competitive in most markets. Innovations in system financing have opened up the residential and commercial solar marketplace to more consumers than ever before, giving all Americans the opportunity to go solar.[27]



A new study from the University of Texas shows that natural gas and unsubsidized wind and solar power are the cheapest source for new generation capacity in 95% of counties nationwide.[28] This is primarily due to the steep decline in the price to install a solar energy system, which has dropped by nearly 70% in the last 5 years.

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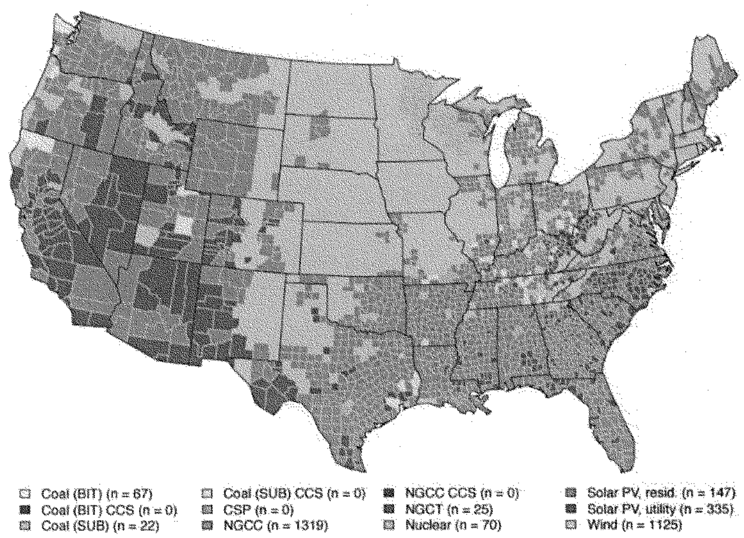
[27] Lazard, Levelized Cost of Energy Analysis, 10.0 (2016), *available at* https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/.

[28] University of Texas at Austin Energy Institute, New U.S. Power Costs: by County, with Environmental Externalities (2016), *available at* http://energy.utexas.edu/the-full-cost-of-electricity-fce/fce-publications/lcoe-white-paper/.

FIGURE 8

Scenario 4: Minimum cost technology for each county, including availability zones, but not including externalities (Equation 1) with reference case assumptions from Table 1.



V. Making the Most of the Nation's Exceptional Solar Assets: Policy Recommendations

As shown throughout this testimony, solar energy is a key component of the nation's energy mix. New solar installations receive a federal investment tax credit (ITC), currently 30 percent of the project's investment costs. The solar ITC is scheduled to phase out over the next four years, reducing to a 10 percent credit for systems owned by a business and no tax credit for systems owned by an individual taxpayer beginning in 2022. While Congress undertakes the complex and challenging task of comprehensive tax reform, we urge it to maintain the current phase-down schedule for the solar ITC. A stable, predictable tax policy for solar energy allows sound investment decisions to be made, furthering the growth of the industry.

The solar industry is currently engaged in a Section 201 "global safeguard" case at the International Trade Commission. Two companies with a small manufacturing presence in the U.S., both subsidiaries of foreign firms, filed a case with the International Trade Commission (ITC) seeking import tariffs that would stifle competition and dramatically increase the price of solar cells and modules. Import duties would be a disaster for the American economy and would jeopardize 88,000 jobs in the U.S. solar industry, including domestic solar manufacturing jobs. Nonetheless, SEIA is interested in pursuing innovative solutions that support American solar cell and module manufacturing while preserving American jobs and the solar success story. Today (October 3, 2017) the International Trade Commission is holding its "remedy hearing" wherein proposals for tariff and non-tariff remedies will be considered. The ITC will issue its recommendation in mid-November. We oppose any tariff that would restrict the flow of freely- and fairly-traded goods.

We support federal energy policies that promote reliability, security and fuel diversity. S. 1460, the *Bipartisan Energy and Natural Resources Act of 2017* takes important steps in this direction. Increased transmission investment will bring greater reliability and access to more diverse sources of generation. In addition, we look to FERC to ensure that well-functioning wholesale electric markets promote thrive and, in parts of the country without RTOs and ISOs, to guarantee open-access and non-discriminatory treatment for independent renewable generators. Finally, incentivizing energy storage deployment on the transmission and distribution grids will increase grid reliability and provide another dispatchable resource to system operators.

VI. Conclusion

Thank you once again for inviting SEIA to submit this testimony. SEIA is grateful for the tremendous public support that solar has across the nation, which is reflected in the great interest and extensive efforts of this Committee. We look forward to working with the Committee to establish the long-term, stable policies needed to make the most of America's exceptional solar assets, delivering solar's benefits to the nation in the form of large quantities of cost-effective, clean and sustainable power, growing numbers of jobs throughout the country, and outstanding economic opportunity.

Mr. UPTON. Thank you.

Next, we are joined by Kelly Speakes-Backman, CEO of Energy Storage Association.

Welcome.

STATEMENT OF KELLY SPEAKES–BACKMAN

Ms. SPEAKES-BACKMAN. Chairman Upton, Ranking Member Rush, on behalf of ESA, thank you very much for your time today. I would like to begin my remarks by level setting our understanding of the terms reliability, resilience, and flexibility.

Our electric system today is bound to a simple reality of physics. Supply must match demand at every moment everywhere. If it doesn't, then the result is equipment damage, service disruption, or blackouts.

So what we call reliability is really the ability to maintain that match of supply and demand during normal operations, even if they are variable or unpredictable.

What we mean by resilience is the ability to maintain service or restore supply during and after a disruptive external event. Flexibility is critical to both reliability and resilience to ensure uninterrupted power is delivered to consumers whenever and wherever they need it.

Energy storage technologies enable energy to be generated at one time and saved for another time. It is pretty simple as that. The concept enables an enormous amount of capabilities for the grid, be it supplying backup power, reducing peak system demands, relieving stressed grid infrastructure, enabling higher penetrations of variable generation sources, or maintaining the optimal function of inflexible generation sources.

These capabilities ensure that supply and demand reliably match during normal operations and make that balance resilient to a greater range of threats.

When most people hear the words energy storage they think of batteries, and for good reason. Batteries are everywhere. They're in our phones. They're in our computers, appliances, our cars, and, increasingly, in our electric grid.

There are a variety of storage technologies including mechanical and thermal, and each has its own performance characteristics and best-suited applications. But all do the same simple job of storing energy, effectively decoupling time—the element of time from supply and demand.

For today, I'm focussing on batteries. There is 800 megawatts of battery storage installed nationwide in—at grid megawatt scale in 21 States.

Storage technologies, primarily lithium ion, are declining rapidly in cost, dropping by 50 percent every 3 to 4 years and projected to continue at this rate.

Driven by these cost declines, the U.S. is forecasted to quadruple its installed storage capacity in just 5 years, representing $3 billion in annual sales.

But more importantly, these sharp cost declines also mean that storage will get larger and perform at longer durations, increasing their range of applications.

Storage is uniquely flexible compared to all other grid resources. Number one, it promotes the reliability and resilience at all levels of the grid and onsite locations.

It could be owned by utilities, third party providers, or consumers for a variety of services and cost-saving applications—the only grid resource that can be used both as supply when discharging and demand when charging.

It's capable of near instantaneous response and precise control, ramping to full charge or discharge in milliseconds. It's capable of near—sorry—a single installation can perform multiple functions, even interchangeably over time, and it can be deployed quickly at megawatt scale within six months.

I provided several examples in my testimony that you can ask me questions about or what have you. But they include maintaining power quality, onsite power, backup power of solar plus storage during the recent hurricanes, locational grid support, demand response with chillers and water heaters, black start capability to enable other generators to return to normal operations, response to short-run grid fluctuations, avoiding outages from system imbalances, transmission and distribution system support during multiyear upgrades, contributions to resource adequacy meeting peak demands, and quick deployment for broader plant failures.

Now, we have a lot of values that we can bring to the grid and with all of these capabilities you would think that storage would be much more prevalent in the market today.

But I will tell you, I think it's still hindered from full deployment. Policy and regulations today focus on what we want from technologies rather than performance.

Because of this, they can't keep pace with the innovation and the changing role of the consumer. We see four general themes to improving the performance characteristics of grid reliability and resilience, which can be competitively and cost-effectively met by storage. More details of these recommendations can be found in my written testimony.

And in closing, I'll just say that energy storage is here, and it's growing fast. We support market-driven pursuit to improve reliability and resilience.

And I thank you for your time.

[The prepared statement of Ms. Speakes-Backman follows:]

Testimony of
Kelly Speakes-Backman

on behalf of the
ENERGY STORAGE ASSOCIATION

before the
United States House of Representatives
Committee on Energy and Commerce
Subcommittee on Energy

Hearing entitled
"Powering America: Defining Reliability in a Transforming Electricity Industry"

October 3, 2017

Energy Storage Association

1800 M Street NW, Suite 400S
Washington, DC 20036
energystorage.org

Summary of Remarks:

- Energy storage technologies enable electricity supplied from any source to be saved for use later, precisely when and where it is most needed.
- There are a variety of energy storage technologies—not only different kinds of batteries, but also mechanical storage and thermal storage technologies.
- The electric grid has distinct and separable resilience and reliability needs. "Reliability" is the ability to maintain operations during normal conditions. "Resilience" is the ability to maintain or restore electric service following a sudden and disruptive external event. "Flexibility" is critical to both reliability and resilience by ensuring uninterrupted power is delivered to consumers when and where they need it.
- Storage today is a cost-effective resource, providing flexibility to meet both the reliability and resilience needs of the grid. There are a multitude of energy storage system installations along the entire grid infrastructure, already providing reliability and resiliency services.
- Battery storage is uniquely capable of instant response to charge or discharge at full power in milliseconds. It located at all levels of the grid and at on-site locations, owned and operated by utilities, private parties and consumers.
- Policies must keep pace with technology and market advances by (1) removing barriers to energy storage participation in markets; (2) designing markets to improve price signals for flexibility and resilience; (3) incorporating the resilience value of distributed energy resources, including storage; and (4) expanding conventional definitions of reliability to capture flexibility and resilience.

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee—

On behalf of the Energy Storage Association (ESA), thank you for the invitation to speak today on the role that energy storage plays in the reliability and resilience of our electric power system.

Since its founding 27 years ago, ESA has been the leading national voice of the energy storage industry working to make a more resilient, efficient, sustainable and affordable grid – as is uniquely enabled by energy storage. ESA promotes the development and commercialization of safe, competitive, and reliable energy storage delivery systems for use by electricity suppliers and consumers. ESA's 150 members comprise a diverse group of power sector stakeholders, including electric utilities, independent power producers, project developers, technology manufacturers, integrators, component suppliers, and system support services—of advanced batteries, flywheels, thermal energy storage, compressed air energy storage, supercapacitors, and other technologies.

Our electric system is bound to a simple reality of physics—supply must precisely match demand at every moment, everywhere. If it does not, the result is equipment damage, service disruption, or blackouts. What we call "reliability" is the ability to maintain that match of electric supply and demand every moment every day, and to do so in the face of variable, unpredictable, and sometimes extreme system conditions. "Resilience" is the ability to maintain or rapidly restore that match of supply and demand following a sudden and disruptive external event. "Flexibility" is critical to both reliability and resilience, to ensure uninterrupted power is delivered to consumers whenever and wherever they need it.

Energy storage technologies enable electricity supplied from any source to be saved for use at a later time, precisely when, where, and in whatever form it is most needed. That very simple concept enables an enormous amount of capabilities for the electric grid—be it supplying back-up power, reducing peak system demands, relieving stressed grid infrastructure, filling in the gaps from variable generation sources, or maintaining the optimal function of inflexible generation sources. These capabilities are, at heart, more efficient ways to ensure that supply and demand reliably match, and to make that balance resilient to a greater range of threats. Indeed, energy storage is the hub of an efficient, resilient, sustainable and affordable energy system that can adapt to any supply mix.

When you hear the word "energy storage," what comes to mind? For most people, they think of a battery—and for good reason. Batteries are everywhere—in our phones, computers, appliances, our cars, and increasingly our electric grid. There are a variety of energy storage technologies[1]—not only different kinds of batteries, such as flow batteries, but also mechanical storage technologies (like pumped hydro and flywheels) and thermal storage technologies (like ice storage and molten salt). Each has its own performance characteristics and best-suited applications, but all do the same job of storing energy for use when it is most needed, be that across seconds, hours, or days. In effect, it decouples the element of time from supply and demand.

[1] Electrochemical energy storage (known as a "battery") converts electricity into a reserve of potential energy by creating an electrical gradient between two terminals separated by an electrolyte; electrons can then be discharged as they separate from ions moving between the two terminals. Mechanical energy storage converts electricity into a reserve of potential energy by pressurizing a substance, accelerating the rotation of a mass, or moving a mass against gravity; the depressurizing of the substance, rotation of the mass, or falling of the mass can be harnessed to turn a generator and produce electricity. Thermal energy storage converts either electricity or heat into a large temperature differential between a mass and its surrounding temperature; that mass can then re-transfer heat to a steam turbine that turns a generator and produces electricity, or the mass can provide direct heating or cooling services. Pure electrical energy storage does not convert electrical input but rather slows the transfer of electrons within an electric field, thereby enabling discharge on demand over short intervals.

For the purpose of today's hearing, I will focus my remarks on the role of battery storage, the fastest growing grid storage technology. Today nearly 800 megawatts (MW) of battery storage are installed nationwide,[2] with megawatt-scale installations in 21 states.[3] This represents nearly 1 GWh of energy storage available for use.[4] Battery storage technologies—primarily lithium-ion batteries—are declining rapidly in cost: dropping by 50% every 3 to 4 years and projected to continue at this rate.[5] Driven by these cost declines, the U.S. is forecast to quadruple installed storage capacity in just five years, representing a $3 billion in annual sales in the U.S.[6] Of greater significance, though, is that sharp cost declines also mean that battery storage will provide ever larger sizes and longer durations more cost-effectively, increasing their range of applications. In fact, the largest battery in the world is currently under development in the U.S. and will capable of providing 100 MW of power for four hours—enough to power 50,000 homes through the peak demands of the day.[7]

Storage is uniquely flexible among all grid resources. *First*, storage is the only resource promoting reliability in every part of the grid: co-located with generation, connected to the high-voltage transmission system, placed on the lower-voltage distribution grid, and located in

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[2] Known capacity additions prior to 2012, in addition to total from GTM Research, *U.S. Energy Storage Monitor: Q3 2017*, Sep 2017, available at https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor

[3] DOE Global Energy Storage Database, accessed 9 Sep 2017, available at http://www.energystorageexchange.org

[4] *Ibid.*

[5] See, for example:

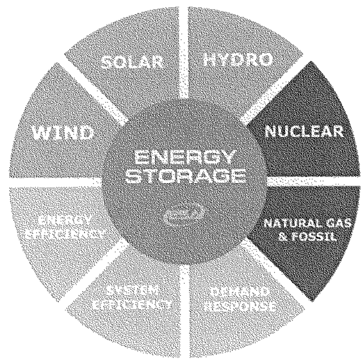
- IHS, *Future of Grid Connected Energy Storage*, Nov 2015, available at https://technology.ihs.com/512285/grid-connected-energy-storage-report-2015
- UBS, *US Battery Storage: Upstream Supply Chain Biggest Winner of EVs*, Oct 2016, available at https://neo.ubs.com/shared/d1Wg6h8EJsbg/
- McKinsey & Bloomberg New Energy Finance, *An Integrated Perspective on the Future of Mobility*, Nov 2016, available at https://www.bbhub.io/bnef/sites/4/2016/10/BNEF_McKinsey_The-Future-of-Mobility_11-10-16.pdf
- O. Schmidt et al., "The future cost of electrical energy storage based on experience rates," *Nature Energy*, Vol 2, 17110 (2017).
- B. Nykvist & M. Nilson, "Rapidly falling costs of battery packs for electric vehicles," *Nature Climate Change* 5 (2015), p 329-332.

[6] GTM Research, *U.S. Energy Storage Monitor: Q3 2017*, Sep 2017, available at https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor

[7] Assumes 6 hours of consumption (5 PM to 11 PM) and average household consumption of 1.23 kW, per 2015 EIA data on annual residential electricity consumption, available at https://www.eia.gov/tools/faqs/faq.php?id=97&t=3

buildings, as well as in microgrids. It is modular and can be scaled to any size, from a home system of a few kilowatts (kW) to a central facility 10,000 times larger. *Second*, storage provides value to all power sector participants: utilities, independent providers, and consumers can all own and operate storage for a variety of reliability services and other cost-saving applications. *Third*, storage is the only grid resource that operates as both supply and demand: supply when discharging and demand when charging, giving it effectively twice the operating range of conventional generation and the unique flexibility to mitigate oversupply as well as undersupply conditions. *Fourth*, storage is capable of near-instantaneous response and precise control, able to ramp its output to charge or discharge at full power in milliseconds. It is that precise control that allows storage to efficiently provide essential reliability services of frequency response, voltage control and ramping, as well as enhance resilience during sudden disruptions.[8] *Fifth*, storage can provide a diversity of functions for the bulk power system, the distribution grid, and end-users, even providing multiple services interchangeably over time to meet the greatest need in any given moment. *Sixth*, storage can be deployed quickly, with build times for MW-scale installations at less than 6 months. Importantly, storage is agnostic to the supply of electricity, and its flexibility can be used to optimize grid functions for any supply mix. That's why we call storage the "bacon of the electric grid"[9] —it makes everything better. Nuclear, coal, gas, wind, solar, hydro, demand response and system efficiency: you name it, storage enhances its utilization.

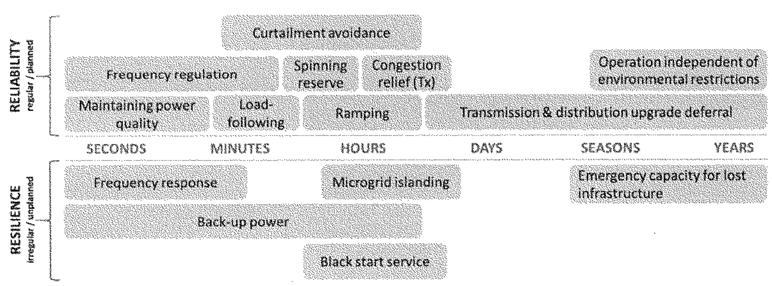
[8] For example, storage can synchronize to the grid and maintain appropriate frequency with even greater fidelity than the mechanical governor devices common to conventional generation that are required in generator interconnection agreements.
[9] Originally attributed to Katherine Hamilton, 38 North Solutions.



Source: Energy Storage Association, 2017

As the Department of Energy's recent *Staff Report on Electricity Markets and Reliability* noted, storage currently provides most essential reliability services, flexibility attributes, and other reliability characteristics under consideration in today's hearing.[10] The flexibility of storage enhances both reliability and resilience.

Flexibility of Battery Storage Addresses Uncertainty at Various Time Intervals



[10] See Figure 4.13, "Mapping Reliability Attributes Against Resources," in U.S. Department of Energy, *Staff Report on Electricity Markets and Reliability*, Aug 2017, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

Source: Energy Storage Association, 2017

The diversity of energy storage system applications along the entire delivery infrastructure is striking, with several examples captured below:

- *Storage maintains power quality and provides on-site backup power to keep businesses, homes, and industrial facilities resilient to service disruptions.* On-site storage can maintain electric service following hurricanes, as happened recently in Florida when homeowners[11] and sheltering sites[12] kept their lights on with solar-paired storage. This is also why Tesla has just sent shipments of hundreds of battery storage systems to Puerto Rico.[13] On-site storage is also especially important for local critical infrastructures affected by electric service disruptions serving its citizens. For example, Irvine Ranch Water District in California is installing 7 MW of batteries at its critical water treatment and pumping infrastructure to ensure continuity for public health.[14] Similarly, New Jersey has installed storage at critical facilities, such as schools, to use as shelter from hurricanes.[15] Microgrids integrating energy storage are demonstrating their capability to operate in island mode, isolated from the larger grid, to maintain service. Recently, utility Ameren islanded its Champaign, Illinois microgrid for 24-hours relying solely on wind, solar, and batteries. Military installations like Ft. Bliss in Texas have incorporated

[11] P. Kelly-Detwiler, "After Irma: Solar Plus Storage - A Small Beacon Of Light In A Sea Of Darkness," *Forbes*, 17 Sep 2017, available at https://www.forbes.com/sites/peterdetwiler/2017/09/17/after-irma-solar-plus-storage-a-small-beacon-of-light-in-a-sea-of-darkness/

[12] J. Dean, "Solar power helped shelter shine through Irma," Florida Today, 24 Sep 2017, available at http://www.floridatoday.com/story/news/2017/09/24/solar-power-helped-shelter-shine-through-irma/694322001/

[13] D. Hull, "Tesla Is Sending Battery Packs to Storm-Ravaged Puerto Rico," *Bloomberg News*, 28 Sep 2017, available at https://www.bloomberg.com/news/articles/2017-09-28/tesla-is-sending-battery-packs-to-storm-ravaged-puerto-rico

[14] P. Maloney, "Tesla, AMS ink 34MWh storage deal with California water system," *Utility Dive*, 29 Sep 2016, available at http://www.utilitydive.com/news/tesla-ams-ink-34mwh-storage-deal-with-california-water-system/427202/

[15] H. Trabish, "New Jersey makes first awards in energy storage program to boost grid resiliency," *Utility Dive*, 24 Mar 2015, available at http://www.utilitydive.com/news/new-jersey-makes-first-awards-in-energy-storage-program-to-boost-grid-resil/378490/

storage into their microgrids to enable similar islanding and mission assurance in the event of energy supply disruptions.[16]

Storage is increasingly distributed throughout the grid to enhance reliability and resilience. For example, during recent heat waves in California, aggregated energy storage has relieved peak demands across the grid, responding with just minutes notice and doing so repeatedly.[17] Similarly, building chillers and water heaters are being increasingly aggregated and deployed as reliable demand response, another form of market-based energy storage. Utilities like Hawaii's HECO are increasingly working with customers who own storage to utilize their assets for distribution grid reliability.[18] By distributing these assets throughout the grid, aggregations of storage are reducing risk of failure of any single, central grid resource. And the advent of battery electric vehicle fleets will push still further in this direction. For example, utility ConEdison is piloting a fleet of mobile batteries that can unplug from one substation and move to another, allowing a grid that can reconfigure around evolving conditions.[19]

- As an example of the recovery aspect of resilience, *storage provides blackstart capability, which restores the grid after system blackouts and enables other generators*

[16] J. St John, "The Military Microgrid as Smart Grid Asset," *Greentech Media*, 17 May 2013, available at https://www.greentechmedia.com/articles/read/the-military-microgrid-as-smart-grid-asset

[17] "Stem Energy Storage Network Delivers Emergency Grid Relief in California Heat," *BusinessWire*, 26 June 2017, available at http://www.businesswire.com/news/home/20170626005354/en/

[18] J. Spector, "Stem Pilot Marks a Step Forward for Commercial Energy Storage in Hawaii," *Greentech Media*, 2 Feb 2017, available at https://www.greentechmedia.com/articles/read/stem-tests-model-for-networked-commercial-energy-storage-in-hawaii-solar

[19] P. Maloney, "How ConEd's mobile battery REV demo could build a new storage business model," *Utility Dive*, 7 Mar 2017, available at http://www.utilitydive.com/news/how-coneds-mobile-battery-rev-demo-could-build-a-new-storage-business-mode/437364/

to turn on again. Imperial Irrigation District installed a 33 MW battery precisely for this role and has successfully restarted its natural gas generators from outage conditions.[20]

- *Storage provides faster, more efficient and cost-effective response to short-run grid fluctuations,* which avoid unexpected outages from system imbalances. In the mid-Atlantic PJM market and in the Electric Reliability Council of Texas (ERCOT) system, fast-responding energy storage is modulating output at every second to maintain a stable grid frequency more efficiently, reducing the need for more Regulation reserves. In the Midcontinent Independent System Operator (MISO), Indianapolis Power & Light is similarly using battery storage to provide fast frequency response,[21] arresting deviations to grid stability from unexpected losses of power plants faster than generators. Particularly in systems where asynchronous generation[22] is increasing, such response capability is increasingly valuable.

- *Storage is also being deployed to help transmission and distribution infrastructure adapt to changing conditions,* maintaining reliability during multi-year upgrades, and deferring or altogether avoiding costly upgrades. For example, utility AEP's Presidio project in Texas and Balls Gap project in West Virginia used batteries to maintain reliable service

[20] P. Maloney, "California muni IID completes first US demonstration of black start battery capability," *Utility Dive*, 19 May 2017, available at http://www.utilitydive.com/news/california-muni-iid-completes-first-us-demonstration-of-black-start-battery/443099/

[21] "IPL Announces Commercial Operation of Battery-Based Energy Storage Array During White House Summit on Renewable Energy and Storage," *BusinessWire*, 16 June 2016, available at http://www.businesswire.com/news/home/20160616006603/en/IPL-Announces-Commercial-Operation-Battery-Based-Energy-Storage

[22] Traditional generation utilizes spinning mass, usually in the form of a turbine, to generate electricity. The rate at which those turbines spin is synchronized to the electric grid's normal operating frequency of 60 Hz, and the inertia in those turbines can moderate deviations in grid frequency. Asynchronous generation either utilize spinning mass that is not inherently synchronized to grid frequency—such as wind turbines—or non-mechanical generation—such as solar photovoltaic modules; such generators use inverters and controls systems to provide their electricity at the same frequency as the electric grid.

while transmission upgrades were completed.[23] Storage has also been deployed to increase the capabilities of the distribution system. For example, the utility Arizona Public Service has deployed batteries at its substations to enable reliable service and avoid wires upgrades as more of its customers install rooftop solar power systems.[24]

- *Storage meets the peak demands of electric grids, contributing to resource adequacy.* Large pumped hydro resources such as Michigan's Ludington Pump Storage Plant have traditionally met this role, charging off-peak to provide eight hours of generation at peak capacity. As costs decline across the industry, a broader array of storage technologies is also fulfilling this role. Lithium-ion batteries are now providing four hours at peak capacity to meet utilities' resource adequacy needs,[25] with those durations expected to increase as prices fall. Flow batteries[26] and molten salt storage[27] are proving capable of more than six hours of peak capacity on the bulk system today.

- *Storage is being deployed to respond quickly to broader infrastructure failures.* After the Aliso Canyon gas storage facility unexpectedly shut down, over 80 MW of battery storage facilities were built in less than six months to make up local capacity shortfalls[28]—a stunning achievement given that it would have taken two or more years

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[23] Edison Electric Institute, *Transmission Projects at a Glance – American Electric Power*, available at http://www.eei.org/ourissues/ElectricityTransmission/Documents/Trans_Project_A-D.pdf#4 and "AEP Milton NaS Battery Energy Storage System," DOE Global Energy Storage Database, available at http://www.energystorageexchange.org/projects/268

[24] "APS, AES bring energy storage to Arizona customers," from website of APS, 8 Dec 2016, available at https://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-aes-bring-energy-storage-to-arizona-customers.aspx

[25] J. Pyper, "Tesla, Greensmith, AES Deploy Aliso Canyon Battery Storage in Record Time," *Greentech Media*, 31 Jan 2017, available at https://www.greentechmedia.com/articles/read/aliso-canyon-emergency-batteries-officially-up-and-running-from-tesla-green

[26] "National Grid Distributed Energy Storage Systems Demonstration - Vionx Energy," from website of DOE Global Energy Storage Database, accessed 28 Sep 2017, available at http://www.energystorageexchange.org/projects/26

[27] P. Fairley, "A Tower of Molten Salt Will Deliver Solar Power After Sunset," *IEEE Spectrum*,21 oct 2015, available at https://spectrum.ieee.org/green-tech/solar/a-tower-of-molten-salt-will-deliver-solar-power-after-sunset

[28] D. Ola, "How California pulled off the world's fastest grid-scale battery procurement - Part II," *Energy Storage News*, 3 May 2017, available at https://www.energy-storage.news/blogs/how-california-pulled-off-the-worlds-fastest-grid-scale-battery-procurement. See also J. Pyper, "Tesla, Greensmith, AES Deploy Aliso Canyon Battery Storage in Record Time," *Greentech Media*, 31 Jan 2017,

for a gas turbine to be deployed.[29] You're seeing the arrival of "just-in-time" capacity additions, which offers grid planners far more flexibility to deal with uncertain forecasts of future needs.

- *Storage is a key resource for supplementing the natural variability of wind and solar resources* as they reach higher levels of installations. Projects like the Hawaii co-op Kauai Island Utility Cooperative (KIUC) solar and storage projects[30] and Texas generator E.ON's wind and storage projects[31] are increasingly common. That said, storage provides this value regardless of where on the grid it is located. For example, standalone storage is increasingly providing ramping services in grids like CAISO, which must efficiently maintain system reliability as gigawatts of solar power steadily come off the system over a short period each evening.[32]

- Of course, *storage is also critical for "baseload" resources like nuclear, natural gas and coal plants.* Since coal and nuclear power are not designed to vary their output significantly or quickly, much of the 20 gigawatts (GW) of pumped hydro storage facilities in the U.S. were built in the latter half of the 20th century to absorb the oversupply from these inflexible resources during periods of low demand. For that

available at https://www.greentechmedia.com/articles/read/aliso-canyon-emergency-batteries-officially-up-and-running-from-tesla-green

[29] Slide 21 of J. Lin, "Energy Storage: Power System Game Changer," presentation at Minnesota Energy Storage Summit 2015, 14 July 2015, available at http://energytransition.umn.edu/wp-content/uploads/2015/06/Energy-Storage-Power-System-Game-Changer-by-Janice-Lin-.pdf#21

[30] G. Bade, "Hawaii co-op signs deal for solar+storage project at 11¢/kWh," *Utility Dive*, 10 jan 2017, available at http://www.utilitydive.com/news/hawaii-co-op-signs-deal-for-solarstorage-project-at-11kwh/433744/. See also R. Walton, "Tesla's dispatchable solar+storage project in Hawaii brought online," *Utility Dive*, 13 Mar 2017, available at http://www.utilitydive.com/news/teslas-dispatchable-solarstorage-project-in-hawaii-brought-online/437858/

[31] P. Maloney, "E.ON to build nearly 20 MW of battery storage at Texas wind farms," *Utility Dive*, 2 Mar 2017, available at http://www.utilitydive.com/news/eon-to-build-nearly-20-mw-of-battery-storage-at-texas-wind-farms/437211/

[32] P. Maloney, "California ISO approves proposals to bolster storage and demand response," *Utility Dive*, 4 Feb 2016, available at http://www.utilitydive.com/news/california-iso-approves-proposals-to-bolster-storage-and-demand-response/413365/

matter, natural gas-fired power plants can operate more efficiently when energy storage reduces the need for cycling those plants. In fact, that's one reason why General Electric has introduced the first gas turbine-battery hybrid unit in the world and why other turbine and engine makers, like Wärtsilä and Siemens, have acquired or merged energy storage businesses. Power companies have co-located storage at their gas plants, like the AES Tait gas plant in Ohio and their Warrior Run coal plant in Maryland.

With all these capabilities of energy storage, you might be wondering: why isn't it everywhere already? Even as prices for energy storage systems have plummeted in recent years, policy has yet to catch up to technology. The electric system was designed before storage was a commonly available and widespread resource, and so the rules governing the grid and electricity markets were developed without contemplating the role of storage. We in the energy storage industry see four general themes to enable storage to contribute further to grid reliability and resilience.

First, we urge policymakers to remove barriers to energy storage participation in electricity markets. Presently, the Federal Energy Regulatory Commission (FERC) is considering a proposed rule[33] directing wholesale market operators to remove regulatory barriers to storage participation. Additionally, FERC is also considering a proposed rule[34] that will update interconnection rules designed for generation to apply more fairly to storage, among other provisions. ESA strongly supports these efforts to ensure physical and market access for

[33] Notice of Proposed Rulemaking, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. RM16-23-000, 157 FERC ¶ 61,121 (2016), available at https://www.ferc.gov/whats-new/comm-meet/2016/111716/E-1.pdf

[34] Notice of Proposed Rulemaking, *Reform of Generator Interconnection Procedures and Agreements*, Docket No. RM17-8-000, 157 FERC ¶ 61,212 (2017), available at https://www.ferc.gov/whats-new/comm-meet/2016/121516/E-1.pdf

storage, which is necessary to maximize the competitiveness of wholesale markets and ensure lowest system costs to households and businesses. At the state level, commissions must remove barriers to customers interconnecting storage to distribution grids and resolve uncertainties over how to treat storage assets for the purposes of utility cost recovery.

Second, we recommend that policymakers design markets to provide more precise and comprehensive price signals for flexibility and resiliency attributes of resources. Wholesale markets, guided by FERC, need to allow resources to compete to provide flexibility and resilience, as well as be compensated for the service provided. Order 755, which established the concept of pay-for-performance in frequency regulation service, could be expanded to other market services. Additional energy market products, such as ramping and load-following, could drive price formation on flexible services. Unpriced reliability services, such as frequency response, should be compensated in a competitive manner when possible.[35] State regulators, for the sake of their ratepayers, should incorporate flexibility and resilience attributes into their cost-benefit analyses of utility investments, as well as consider rate designs that better align customer behavior with both local and system needs. And both FERC and state regulators should develop frameworks enabling storage to provide its multiple services, be that as both a wholesale and retail asset[36] or as both a transmission and generation asset.[37]

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[35] ESA notes that FERC is presently considering a proposed rule that would compel all assets to possess frequency response technical capability without compensation, which undermines any future effort to develop a market product for frequency response. See Notice of Proposed Rulemaking, *Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequency Response*, Docket No. RM16-6-000, 157 FERC ¶ 61,122 (2016), available at https://www.ferc.gov/whats-new/comm-meet/2016/111716/E-3.pdf

[36] FERC is considering rules presently regarding storage providing both wholesale and retail service in Notice of Proposed Rulemaking, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. RM16-23-000, 157 FERC ¶ 61,121 (2016), available at https://www.ferc.gov/whats-new/comm-meet/2016/111716/E-1.pdf

[37] FERC has previously provided guidance on storage operating as both transmission and generation; see Policy Statement, *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery*, Docket No. PL 17-2-000, 158 FERC ¶ 61,051 (2017), available at https://www.ferc.gov/whats-new/comm-meet/2017/011917/E-2.pdf

Third, we recommend that policymakers consider the contribution of distributed energy resources (DERs) to system reliability and resilience. Most of the electric reliability problems that households and businesses experience arise from the distribution system, not the bulk power system. As the prevalence of DERs increases, storage can play a critical role in risk management and assuring the continuity of service for communities. And as DERs increasingly participate in wholesale markets, FERC and NERC should consider the contributions they can provide to bulk power system reliability as well.

Fourth, we recommend that policymakers consider expanding the definition of reliability to capture resilience and the need for flexibility, in light of a transforming electric system. As variable generation increases to higher levels of penetration and as consumers evolve into prosumers, grids must be more flexible to react to more frequent short-duration changes to net demand. There is a greater value to flexibility that may not be met adequately by resources designed only to meet system peak. For example, New Mexico utility PNM's integrated resource plan recently assessed the capability of its fleet to respond to (1) events caused by not having enough available resource capacity (i.e., resource adequacy), and (2) events caused by not being able to respond quickly to meet the variable nature of higher levels of renewable resources. In so doing, PNM was able to more accurately determine conditions when storage is more cost-effective than gas capacity for providing reliability.[38] When reliability contemplates resilience and flexibility as well as resource adequacy, optimal portfolios may seek to include storage more readily than they would otherwise. CAISO has introduced a flexible resource

[38] See analysis in Tables 41 and 42 in *PNM 2017-2036 Integrated Resources Plan*, 3 July 2017, available at https://www.pnm.com/documents/396023/396193/PNM+2017+IRP+Final.pdf/eae4efd7-3de5-47b4-b686-1ab37641b4ed#128

adequacy concept, which is an additional set of resources intended to meet reliability and resilience needs under a high-renewables world.

Energy storage is here and it is growing fast. We are at a moment where the U.S. can take advantage of this new technology to cost-effectively enhance the reliability and resilience of our electric system with any mix of supply resources. I thank the Committee for the opportunity to speak to these critical issues, and I welcome your questions.

Mr. UPTON. Thank you.

Last, we are joined by Mr. John Moore, Sustainable FERC Project, Energy & Transportation Program from the NRDC.

Nice to see you.

STATEMENT OF JOHN MOORE

Mr. MOORE. Thank you very much, Mr. Chairman Upton, Ranking Member Rush, and members of the subcommittee. I appreciate the opportunity to testify here today.

One thing I think I can say after listening to everyone else on the panel is that we all agree that reliability and resiliency is critical as our grid continues to transform and that we need to have the ability to maintain a secure system and then quickly recover whenever extreme weather, physical attacks, or cyberterrorism attack on the grid.

I think, though, that if Hurricanes Irma and Harvey proved anything, it is that no resource actually is perfectly resilient or reliable, and actually some resources have more vulnerabilities than we might think.

In point of fact, several nuclear units suffered during Irma and Harvey and didn't return to service until days afterwards. We've already heard from Mr. Kiernan.

Saturated coal piles forced the power plant to switch over to natural gas, and then distribution and transmission systems also can create havoc with reliability and resilience as we've seen in Puerto Rico and parts of Florida as the grids were knocked offline.

The key question—and now I'm going to turn to the DOE study because that's the topic of the day—the key question is whether massive subsidies of the type that the DOE proposes to—proposes for the grid would have made any of these power plants more reliable or resilient and better able to withstand natural forces.

No. It actually might have made the problem worse by undermining markets and freezing out other equally reliable and less costly resources.

We can achieve the same level of reliability at a lower cost by first defining reliability services and then deciding—and then designing markets around those needs. I think you have already heard a couple of witnesses testify to that fact.

Now, to our specific concerns about the Department of Energy's proposal, it would send billions of dollars each year to outdated technologies without any evidence that these payments are necessary.

It would supplant FERC's competitive electricity markets with an anticompetitive command and control system that decides what plants open and close by direction of the Federal Government.

You know, I wonder what's happened here to States' rights to choose their own resource—to make their own resource adequacy decisions.

Illinois, for example, restructured in 1997 and made the decision to link to FERC's market design. Now the Department of Energy is telling them too bad, we are going to make your customers pay billions of dollars more for something that they don't want or need. That, to me, is resource adequacy masquerading as resiliency.

Third, I am very concerned that this would politicize an independent agency in a way never before seen. FERC's independent system of competitive markets to channel customer dollars towards the cheapest generators able to meet customer needs would be replaced with a more arbitrary system marked by market crashes and peaks that could change with every administration.

In this reliability the goal of DOE's proposal could be compromised as politics, not technical assessments, would govern payment for grid services.

So in conclusion, if we want a truly resilient electric grid, moving to a low-carbon future will help us get there by reducing the risk of extreme weather and other disruptive events fueled by climate change.

Focus on grid reliability in resiliency services and next-generation market designs coupled with smartly planned transmission needed to deliver high levels of clean renewable energy to market, and protect States' rights to make their energy choices.

Thank you.

[The prepared statement of Mr. Moore follows:]

Testimony of John Moore
Senior Attorney and Director of the Sustainable FERC Project
at the Natural Resources Defense Council
Before the Committee on Energy and Commerce, Subcommittee on Energy
United States House of Representatives
October 3, 2017

Part 2: Powering America:
Defining Reliability in a Transforming Electricity Industry

Thank you for the invitation to appear before the Subcommittee on Energy to discuss important power grid resilience and reliability issues in a transforming electricity system. I would like to emphasize several points in my testimony:

- Reliability and resilience are related concepts. They should be defined and addressed in a way that avoids redundant compensation or regulation. To a significant extent, existing reliability standards and practices already include resilience considerations, and these concepts must continue to be viewed in a coordinated way. Notably, we have maintained and strengthened reliability during the ongoing transformation of the electricity system.
- Baseload power is not a technically-based reliability standard, unique grid service, or resilience attribute. Policies and investments preferencing "baseload" resources simply because they can run at a high, sustained operating level (including times when load is at a minimum) will increase customer costs and pollution without adding any resilience benefits.
- Resilience must not be used as a pretext for rent-seeking behavior by non-competitive generators. Yet the Department of Energy's ill-considered plan to subsidize coal and nuclear plants (released Sept. 29, 2017) is exactly this sort of pretextual rent-seeking proposal and should be rejected.
- Flexibility should be prioritized in market design.

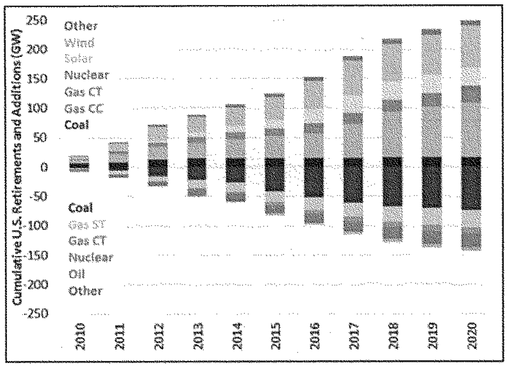
In summary, continuing the transformation of the nation's power grid to facilitate a low-carbon future will improve reliability and resilience in the long run by helping to prevent and reduce outages caused by the increase in extreme weather and other disruptive events.

Chairman Upton, Ranking Member Rush, and members of the Subcommittee, thank you for the opportunity to share the views of the Natural Resources Defense Council (NRDC) on electric power grid reliability and resilience. My name is John Moore, and I am a Senior Attorney at NRDC and the director of the Sustainable FERC Project.

NRDC is a national, non-profit environmental organization with more than 3 million members and engaged community participants. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC's top institutional priorities include curbing global warming and creating a clean energy future. The Sustainable FERC Project is an education and advocacy initiative housed within NRDC with a mission of removing ongoing barriers to the deployment of zero-carbon renewable energy and demand-side resources on, and accessible through, the nation's bulk electric power system. We focus on the regulatory policies of the Federal Energy Regulatory Commission (FERC) and entities subject to FERC jurisdiction.

NRDC supports a resilient, reliable, secure, and clean power grid. Since 2010, our nation has added approximately 200 gigawatts (GW) of new power plants (including many gigawatts of rooftop solar), while retiring 123 GW of older, dirtier, and costlier power plants, and many more GWs will continue to be added to our power system in the future:[1]

[1]Source: Brattle Group, Advancing Past Baseload to a Flexible Grid, at 13 (June 26, 2017), available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498482432. Graph reflects Brattle Group analysis of data compiled by ABB, Inc., The Velocity Suite, June 2017. Gigawatts reflect nameplate capacity. Solar additions represent utility-scale solar. Future additions reflect units currently under construction, undergoing site preparation or testing, and permitted.



At the same time, our nation is increasing the efficiency of our energy use to reduce our power consumption. Newer resources like energy storage in all its forms and demand-side management also are taking root.

1. The importance of distinguishing between reliability and resilience

Reliability and resilience are complementary but different concepts. Both are essential needs, but they should be defined and provided for in a manner that avoids redundancy and confusion. A *reliable* grid can withstand sudden disturbances such as short circuits or loss of generation, transmission, and other system components without a loss of load. A *resilient* grid minimizes the magnitude and duration of outages when grid disruptions occur. The term resilience is also sometimes used to describe the ability of the system to withstand severe weather and other events. Aspects of resilience overlap with reliability, which focuses on the ability of the system to continue running during unexpected events. So, to a large extent, consideration of resilience is not new, and it has historically been part of the existing reliability roles of FERC and the North American Reliability Corporation (NERC).

In defining and regulating reliability and resilience, it makes sense for system operators, FERC, and NERC to account for not only the need to stay running (reliability), but also the resilience concepts of limiting the magnitude and duration of outages. Doing so, as opposed to a narrower focus only on the frequency of system outages, enables a system that satisfies customers at the lowest cost.

While the tradeoffs are complex, one can intuitively understand that many of us would rather have the power go out at our house for 5 minutes once every three years than experience a power outage once every 10 years but have that outage sustained for weeks on end. Planning for both reliability and resilience in this way allows regulators to make these tradeoffs in an intelligent way while prioritizing the way markets channel customer dollars.

However, in considering the second aspect of resilience—the ability to keep the lights on during severe weather events and other grid disruptions—these entities need to be extremely careful to avoid redundant compensation mechanisms, operating standards, or regulations. Part of the core responsibility of ensuring reliability is setting a standard by which extreme events (such as a heat wave) only cause outages very infrequently. Separate 'resilience' and 'reliability' standards, if formulated under this overlapping usage, could cause inefficiencies or even result in paying resources twice for providing the same service.

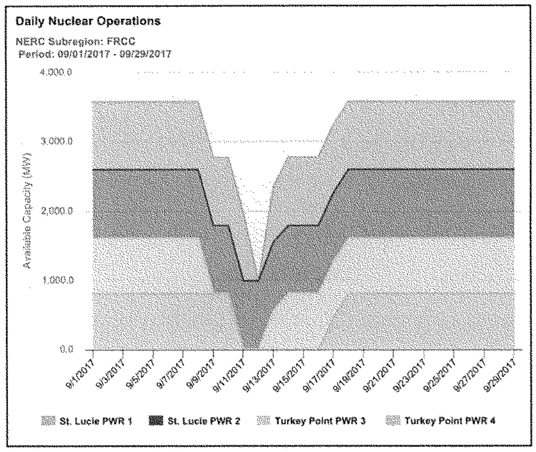
NERC with FERC oversight, identifies, implements, and refines reliability standards to maintain service and reduce outages. With FERC approval, NERC currently oversees over 100 mandatory standards related to the operation and planning of the grid, representing 1,500 discrete requirements. They were developed by technical experts, and they are approved and enforced by NERC and FERC. NERC also investigates system resilience, especially in the wake of major grid disruption events.

Many of NERC's reliability standards address system planning and other minimum requirements for ensuring the predictable and trouble-free operation for a system often described as the world's most complex machine. Some of NERC's reliability standards can be said to include an element of resilience by strengthening the ability of the grid to provide uninterrupted service. For example, grid operators design the system to withstand the failures of multiple elements of the system (N-1-1 contingency). They also plan for extreme events causing the loss of additional elements. NERC's design criteria recognize that a system element can fail for any reason, including equipment failure, line overloading, weather, falling trees, physical attacks, or even animals short-circuiting the line. In considering resilience, NERC and FERC must be careful not to duplicate these standards or create inconsistent rules.

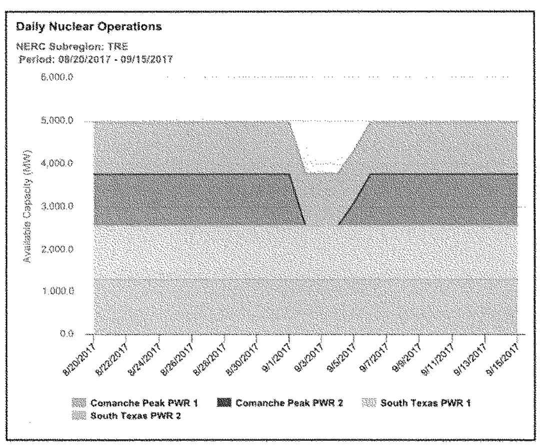
In view of the extremely active and ongoing work of NERC and other grid reliability authorities on reliability and resilience, we recommend that Congress leave the core responsibilities of defining and compensating reliability and resilience services to FERC and NERC. Congress can, however, ensure that DOE has adequate resources to research additional grid resilience and reliability improvements. Congress also should encourage DOE to continue to incent new technologies and grid structures, such as microgrids, that could achieve a reliable and resilient system at lower cost. Further, in providing aid to rebuild in the wake of disasters, such as the recent hurricanes impacting Texas, Louisiana, Florida, and Puerto Rico, Congress should consider how reconstruction can occur in a manner that best ensures future reliability and resilience.

Congress also should keep in mind at least two key facts related to resilience. **First, no type of central station power plant is immune to weather-related disruptions.** For example, several nuclear power plant units had to be taken off-line in preparation for Hurricane Irma and were out of service for up to six days:[2]

[2] Source: Data drawn from SNL Energy, "Daily Nuclear Operations" (*subscription required).*



Similarly, as a result of Hurricane Harvey, two units had to come off-line because of the intensity of the storm:[3]



[3] Source: Data drawn from SNL Energy, "Daily Nuclear Operations" (*subscription required).*

Also during Harvey, the onsite coal pile at the W.A. Parish plant in Texas became so saturated with rainwater that the coal could not be delivered into the storage silos, forcing the plant to switch to natural gas for the first time in 8 years.[4] In numerous cases, it was transmission lines, not generators, that were the point of failure due to storm damage. Finally, as is well-known, coal piles froze during the Polar Vortex. Conversely, wind has performed well during both cold and warm extreme weather events. For example, wind power plants near the Texas coast survived Harvey largely unscathed, despite facing 110 miles per hour winds. Also, demand response performed very well during the 2014 Polar Vortex.

Second, electrical distribution systems are responsible for over 90 percent of total electric power interruptions.[5] This is not surprising, since they are, by their very nature, more vulnerable to outages than the transmission system. Due to the high cost of redundancy, distribution systems are not designed with the same level of reliability and resilience as the transmission network.[6] This suggests that efforts to ensure reliability and resilience during extreme weather should focus largely on the distribution system rather than on any particular type of generation system. Transmission lines also suffer outages that exceed NERC reliability standards (as happened in Texas during Harvey), and in those instances, outages can be of significant duration and magnitude.

[4] https://www.platts.com/latest-news/electric-power/houston/harveys-rain-caused-coal-to-gas-switching-nrg-21081527.

[5] DOE, Quadrennial Energy Review, Second Installment (January 2017), at 4-2, available at https://energy.gov/epsa/quadrennial-energy-review-second-installment.

[6] Brattle Group, Electricity Baseline Report for the US Power System, at 4 (April 2015), available at http://www.brattle.com/system/publications/pdfs/000/005/393/original/Electricity_Baseline_Report_for_the_US_Power_System.pdf?1484245617.

In all cases, monetizing specific grid resilience services through market design changes should be avoided unless the need is clearly researched, defined and distinctly articulated as separate from reliability services that are already compensated through the market.

2. We have maintained reliability during a transforming electricity system

Through the continuing transformation of the system resource mix, system operators have been able to meet the industry's high reliability standards. This is not surprising since they did so during the expansion of coal and gas in the 1970s and 1980s and during the gas boom in the 2000s. In all cases, planners and grid operators identify needs to meet reliability standards and best practices, and they must develop planning, market, and operation solutions to meet those needs in a resource-neutral manner.

Experience in the United States confirms that high levels of renewables like wind and solar can be reliably integrated into the system while offering valuable grid services. The Brattle Group's 2017 report, Advancing Past "Baseload" to a Flexible Grid, supports this conclusion, noting that renewable integration efforts are stimulating innovations that bring additional system benefits. [7] These benefits are only achievable by moving past the status quo.

The Subcommittee also should be aware that comparatively little backup power in the form of reserves is necessary to integrate high levels of renewable energy into the grid. Indeed, grid operators often require more backup power for large baseload power plants than for wind and solar facilities. Why? Wind and solar units are collections of many individual turbines and panels, which means that the failure of one or two turbines or a set of panels will have little

[7] Brattle Group, Advancing Past Baseload to a Flexible Grid, at iii (June 26, 2017), available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498482432.

impact on the facility's total output. In contrast, the electricity output changes from coal and nuclear power plants, though less frequent, are larger, abrupt, and sometimes unpredictable.

3. "Baseload" is not a reliability or resilience standard

Baseload power is not a technically-based standard. Policies and investments preferencing the "baseload" supply resources in the name of resilience, but on the sole basis of their status as "baseload", will raise consumer costs without commensurate resilience benefits. In the past, when coal and nuclear power were perceived to be the least costly way to supply power, grid operators planned around these large units to serve baseline system needs (referring to them as "baseload" units because they operated at a high, sustained output level that served the baseline load; i.e. minimum demand was served primarily by "baseload" resources). Operators built or contracted with more expensive "intermediate" and "peaker" units to meet variations in system need because the baseload units were inflexible and could not be ramped up and down to meet these changes. Because other units were also capable of contributing production during periods of minimum demand, the only compelling reason to have units dedicated to serving this "base load" was that the inflexible units were perceived to be cheaper.

But today, coal and nuclear units are frequently not the least expensive option. Low natural gas prices, flat electricity demand and more efficient energy use, declining renewables costs, and stronger climate and public health protections are all driving an irreversible shift in the underlying economics of the electricity industry. Because of these trends, Brattle Group, a global economics consulting firm, has concluded that describing generation as "baseload" is no longer helpful for purposes of planning and operating today's electricity system.[8] Economics frequently

[8] See Brattle Group, Advancing Past Baseload to a Flexible Grid, at 13 (June 26, 2017), available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498482432.

dictate that a different mix of units serves the base load (minimum demand) at different times, so the term is confusing without providing any helpful information to grid planners.

A resource-neutral grid planning framework that focuses on services like providing power at times of peak demand is a better approach than preferencing resources because of labels like "baseload." For example, in regions with competitive markets, market prices dictate the cheapest mix of resources to meet needs at any given time, while reliability requirements ensure that enough units are available to ensure that a blackout never occurs. This framework rewards "baseload" plants only where they are truly needed, but prioritizes other resources when it is more cost-effective to do so.

The Department of Energy Staff Report to the Secretary on Electricity Markets and Reliability suggested a technology-neutral framework for "baseload generation," defining it as "power plants that are operated in baseload patterns," meaning "plants that run at high, sustained output levels and high capacity factors, with limited cycling or ramping."[9] But the report never explains why grid planners or operators should endeavor to classify this category of plants. In fact, the concept cannot be defended. There is no reason to meet load with plants that run at high, sustained output levels as opposed to a mix of units that run at variable levels but combine to serve system demand at any given time. The market can and will choose the mix of resources that meet load at lowest cost. If anything, the inflexible nature of units traditionally known as "baseload" is a negative feature that hampers their ability to serve system needs such as ramping. Giving "baseload" units different regulatory treatment, such as compensation solely on that basis, would increase costs for customers without providing any commensurate benefits.

[9] Department of Energy Staff Report to the Secretary on Electricity Markets and Reliability, at 5 (August 2017).

To be clear, this is not to say that "baseload" units do not provide valuable services to the grid. They do, and should be compensated accordingly. (There also may be historical reasons why baseload resources are more prevalent in some areas.) But, compensation for those services should be provided in a resource-neutral manner that addresses the specific need being served (for example, frequency response, production at times of peak demand), *not* because a plant happens to operate at a high, sustained output level, which, as noted earlier, is an arbitrary distinction. As Chairman Chatterjee affirmed in testimony before the Subcommittee last month, the Federal Power Act requires FERC to act in a fuel neutral manner, which means avoiding discriminating between types of generation.

This requirement prohibits compensation based on categorization of units according to criteria such as "baseload," even if they are framed according to technology-neutral criteria such as the ones proposed by the Department of Energy Staff report. This is because those criteria are not linked to any specific grid services, meaning that the inherent purpose of such classification would simply be to prefer those types of resources that fell within the classification. Similarly, FERC could not create a "resource neutral" framework to provide special compensation to resources that operate during the day when the sun is shining, and then ramp down capability at night. Compensating units for the services that they provide should not involve developing a classification system for "baseload" or any other arbitrary category based on generation profiles, which would simply increase customer costs and discourage innovation.

Such compensation also would incur significant opportunity costs, since dollars spent on-site fuel storage or another asserted attribute are dollars not invested in other activities that could contribute much more to grid resilience. Said another way, mandating additional compensation for on-site storage without conducting a comprehensive comparison of options for enhancing grid resilience could interfere with much more important actions to improve grid resilience. By focusing instead on operational needs rather than specific fuels or technologies, grid operators and planners can leverage and incentivize the full range of resources capable of meeting those needs, thereby reducing costs and incentivizing innovation.[10]

4. Resilience must not be used as a pretext for rent-seeking behavior by non-competitive generators

Recently, market forces such as low natural gas prices have put resources traditionally known as "baseload" resources under economic pressure. But the question of whether resources have enough revenues to continue to operate or will retire is entirely different from the question of whether a specific unit is needed to maintain the reliability of the system (which is dealt for by FERC and NERC regulations). As certain types of units become uncompetitive, owners of those units may seek payments or other regulatory preferences under the pretext of reliability or resilience even when they are not the most reliable or economic way to supply reliability or resilience.

But preferencing any resource in markets by compensating or otherwise advantaging resources that display specific characteristics simply because of the perceived contributions of any one source to overall system reliability or resilience, begs the question of whether other units or technologies could provide the same level of resilience at a lower cost. Defining resilience and reliability services in a truly resource-neutral manner allows the market to answer that question.

Baseload resources are not necessarily resilient, as extreme weather events show. Indeed, even if the grid operator had paid the coal or nuclear resource premiums at the time of the event,

[10] It also is worth emphasizing that energy efficiency supports a resilient and flexible grid for the simple fact that more energy efficiency reduces the need for any supply resource and the attendant transmission infrastructure. Increasing end use efficiency extracts more energy value for each unit of power generated by any supply resources. Energy efficiency also brings other benefits, including lower consumer bills, lower peak demand, less water and air pollution, and fewer land use impacts.

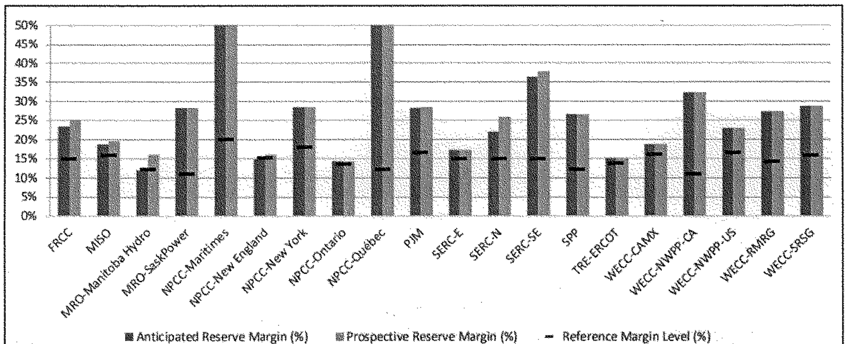
it is unlikely that they would have had any effect on assuring their performance and reducing their forced outage rate. In the case of PJM, it created new rules to improve the performance of their gas and coal fleet (such as requiring cold weather protections) precisely because they were more vulnerable to disruptions than wind, nuclear, and demand response in an extreme cold weather event. PJM first boosted the performance of its generators in extreme weather conditions through operational fixes and requirements, rather than by market enhancements, to improve operational reliability and reduce forced outages. These steps included:

- Performance verification or testing during and before cold weather;
- Better gas unit commitment, communication, and coordination;
- Validation of unit fuel source, operating limits, and outage types;
- Confirmation of the availability of resources outside of PJM able to supply energy and capacity into PJM.

PJM also made numerous improvements for performance in hot weather, including: more accurate estimates of synchronized reserves; better communication and notification protocols; more information on unit characteristics and limitations; updates to PJM's system modeling; and improvements to PJM emergency procedures tool. None of these changes required out-of-market compensation or premiums for specific resources.

Currently, there is little evidence of a resource adequacy shortfall. All regions of the country meet, and in some cases, substantially exceed their target reserve margin: [11]

[11] North American Electric Reliability Corporation, 2017 Summer Reliability Assessment, at 7 (available at http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2017%20Summer%20Assessment.pdf.



Summer 2017 Anticipated/Prospective Reserve Margins Compared to Reference Margin Level

Further, the interconnection queues of the three largest RTOs in the eastern interconnection (PJM, MISO, and SPP) reflect the continuing bullish investor and developer outlook on new generation builds, with over 166 GW of wind, solar, and natural gas projects in the queues.[12] MISO's queue, for example, includes 28.6 GW of wind, 14.9 GW of solar, and 11.5 GW of gas. Even if only a fraction of the resources are built (as is often the case), these high levels suggest confidence, not crisis.

Flying in the face of these facts, on September 29, 2017, DOE proposed a massive subsidy program for economically ailing coal and nuclear power plants.[13] The proposal requests FERC to issue a final rule within 60 days to prop up "fuel-secure resources," which must have "a 90-day fuel supply on site enabling [them] to operate during an emergency, extreme weather conditions, or a natural man-made disaster."

DOE's unprecedented move is couched under a false premise that plants with fuel located on site are needed to guarantee the reliability of the electricity system. According to the proposal,

[12] MISO (https://www.misoenergy.org/Planning/GeneratorInterconnection/Pages/InterconnectionQueue.aspx); PJM (http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx); SPP (https://sppoasis.spp.org/documents/swpp/transmission/GENInterPAGE.CFM).

[13] https://energy.gov/articles/secretary-perry-urges-ferc-take-swift-action-address-threats-grid-resiliency.

"[t]he resiliency of the nation's electric grid is threatened by the premature retirements of power plants that can withstand major fuel supply disruptions caused by natural or man-made disasters." But consistent with NERC's findings noted above, DOE's own grid study this year found that all regions of the country have an *excess* supply of energy resources needed to meet demand. Furthermore, while it included a brief discussion of the potential benefits of on-site fuel supply, it also highlighted examples of units with on-site fuel supply *failing*, such as coal plants that could not operate during the 2014 Polar Vortex when their fuel supplies froze in the extreme cold.

DOE's proposal would be a radical departure from the way FERC currently regulates electricity prices. Under FERC's system, electricity prices are governed by competitive market forces. A power plant is only insulated from this system by FERC under extremely limited circumstances, where a detailed examination of the grid reveals that the plant is needed for reliability purposes. The plant is then guaranteed its costs of operating only on a temporary basis, until a replacement for the unit can be constructed.

Moreover, if adopted, DOE's proposal would wholly undermine FERC's carefully-constructed market system. It would essentially ensure that coal and nuclear plants in regions encompassing most of the country continue to run even where they are too expensive to compete in the energy market. And it would saddle customers with higher costs, while posing obstacles to the integration of cleaner and less risky energy sources such as solar and wind.

More generally, interventions such as the DOE proposal have several major drawbacks and risks which make them so undesirable. Their problems include:

- Increasing carbon and other pollution;
- Increasing customer costs without offering corresponding benefits;

- Exacerbating the problem they seek to solve by undermining trust in market signals and destabilizing the investment climate for the future; and
- Creating oversupply, by reducing prices mutes the price signal for flexible supply and demand resource options.

5. Flexibility should be prioritized in market design

Studies demonstrate that encouraging flexible energy resources holds the potential to better serve customers while reducing system costs. Congress should encourage market designs that better compensate flexibility by funding Department of Energy studies to examine grid services and technologies capable of meeting these needs.

The Brattle Group's 2017 report, Advancing Past "Baseload" to a Flexible Grid, demonstrates how grid operators are reducing costs and more reliably serving customers by designing markets and planning procedures around more precise definitions of system needs.[14] As Brattle explains, studies demonstrate that "flexibility" -- the ability to deliver power and ramp-up supply or reduce demand quickly in response to system fluctuations – is increasingly valuable. An increased focus on flexibility holds the potential to improve reliability and reduce costs. A recent study of California's grid found that as flexibility increases, reliability improves and both production costs and emissions decrease.[15] Analysis of New Mexico grid operations reached a very similar conclusion, finding that over time, operational flexibility will be increasingly important in avoiding load curtailment and blackouts.[16]

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[14] Brattle Group, Advancing Past Baseload to a Flexible Grid (June 26, 2017), available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498482432.

[15] Flexibility Metrics and Standards Project (January 2016), available at www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=9282.

[16] PNM Preliminary Reliability Analysis (April 2017), available at https://www.pnm.com/documents/396023/3306887/04182017-irp-mtg-reliability/66b6bdc0-d9d4-4f72-b1dc-076d8c5c74c2.

Coal and nuclear units are limited in their flexibility because they tend to have high start-up and shut-down costs, as well as operational limitations; so, they generally cannot provide the full suite of grid services offered by nimbler flexible resources like energy storage. While nuclear and coal do support system reliability, this value is not unique. Brattle's conclusion is that grid operators should let supply compete in a technology-neutral manner to provide grid reliability.

Conclusion

I want to again thank the Committee for inviting me to testify today on these important grid reliability and resilience issues. Continuing the transformation of the power grid to facilitate a low-carbon future will improve reliability and resilience in the long run by helping to prevent and reduce outages due to the increase in extreme weather and other disruptive events. A diverse and fuel-neutral mix of "flexible" resources will be a key ingredient in this transformation. I look forward to discussing them with the Committee during the hearing.

Mr. UPTON. Thank you all, and now we will move to questions.

I want to be relatively quick on these first two. So last week—Friday—DOE issued a notice of proposed rulemaking to FERC with a 60-day timeline. FERC then re-docketed the notice of proposed ruling with a 20-day deadline for initial comments. I would note that a typical FERC proposed rulemaking has a 180-day deadline.

If you were king, what would that number be for this order that came out Friday? And Mr. Durbin, we will start with you, just to——

Mr. DURBIN. Well, we joined several of the groups here and others around town making a motion to FERC asking for a 90-day.

Mr. UPTON. Ninety-day. Mr. Bailey?

Mr. BAILEY. Being king, I don't have a number for you, Mr. Chairman. I honestly don't.

What we have said is that this needs to be done very, very quickly. That's all I can say to you.

Mr. UPTON. Of course. I probably should have said queen or king for the day. Sorry.

Ms. KORSNICK. That's OK. I am good with king.

Mr. UPTON. OK. All right.

Ms. KORSNICK. I think the most important thing is that we allow for the appropriate conversation to play out, and at the same token, as we said, there is a sense of urgency.

So I think somewhere in the neighborhood of 60 to 90 days is appropriate.

Mr. UPTON. Mr. Kiernan?

Mr. KIERNAN. We support the 90-day approach, as Mr. Durbin mentioned. I'll also just emphasize this needs to be thoughtfully considered.

Obviously, the wholesale power markets—extraordinarily important and complex, and there needs to be a good healthy thoughtful deliberative process so that we end up with a competitive market that works.

We worry about some rush to judgment that might support one fuel source or another. That is not the right approach.

Mr. UPTON. Mr. Wright?

Mr. WRIGHT. NHA doesn't have an official position on number of days. But I think it's pretty clear, I hope, from my testimony that trying to figure out how you get to reliability requires you to provide all those different services that are necessary and that is a complex conversation.

And then in addition to that, it's a regionally based conversation because we have different issues in different parts of——

Mr. UPTON. You're sounding like a politician.

Mr. Mansour?

Mr. MANSOUR. Mr. Chairman, actually, with the notice that we filed along with some of the other groups here, it was 90 days for the initial comment period plus another 45 for responses.

So and actually, 90 days is probably not sufficient in any case. This is an extremely large undertaking. It's a huge change in the way markets would work and FERC should take their time and they should hold a technical conference on this. They should allow for a maximum amount of public comment and input from a range of stakeholders.

Ms. SPEAKES-BACKMAN. I will—well, first, to answer your question I would say—directly I would say 90 days is—would be sufficient for us to be able to rush through and answer.

But I will also—I would also like to add that especially based on the DOE staff report, we believe that resilience should really encompass much more than just fuel supply and so—and resilience is a—is a large issue and a large problem that we need to consider.

It's a lot more complicated than simply the fuel supply, and for that reason we think there needs to be more time given to this.

Mr. UPTON. Mr. Moore?

Mr. MOORE. Sure. It probably doesn't surprise you to—for me to say that if I were king I'd probably put it in the trash can because I don't think it meets minimum standards of due process in the Administrative Procedure Act, along with the fact that other RTOs like PJM and ISO New England where many of these plants are located are working diligently on this now, in all seriousness.

Mr. UPTON. The DOE staff report found that FERC should expedite its efforts regarding its price formation efforts. Additionally, DOE has recently filed a notice of proposed rulemaking with FERC, as we know, directing FERC to accurately price generation resources necessary to maintain reliability and resiliency.

Yes or no, do you support FERC implementing DOE's filed NLPR as written? Some of you talked about that in your testimony but some of you did not.

Mr. DURBIN. If it is yes or no, the answer is no. I, again, think that this was the—what they asked for on Friday was totally inconsistent with what—with the study they put out in August.

Mr. UPTON. Mr. Bailey?

Mr. BAILEY. Yes, sir. With a huge caveat, we are still looking at it. If the two answers are yes or no, I would—I would say yes.

Mr. UPTON. Ms. Korsnick?

Ms. KORSNICK. We think it's a good baseline but we think additional conversations need to be had through the rulemaking process.

Mr. UPTON. Mr. Kiernan?

Mr. KIERNAN. No, we do not, and I would just add an example. The technological advances of wind energy show that you want to allow the markets to compete and evolve and not pick one fuel source over another.

Mr. UPTON. Mr. Wright?

Mr. WRIGHT. No on the process. Yes on the substance of it's a good idea to address price formation.

Mr. UPTON. Mr. Mansour.

Mr. MANSOUR. It would have to be no on the process and no on the NOPR itself. Let the markets run.

Mr. UPTON. Ms. Speakes?

Ms. SPEAKES-BACKMAN. No as written.

Mr. UPTON. Mr. Moore?

Mr. MOORE. I think majority wins. No.

Mr. UPTON. OK. My time is expired.

I yield to the ranking member of the subcommittee, my friend, Mr. Rush.

Mr. RUSH. I want to thank you, Mr. Chairman.

Mr. Moore, in your written testimony, you state that the Nation's power grid to continue to transform towards a low-carbon future that will improve reliability and resilience by helping to prevent and reduce outages caused by the increase in extreme weather and other disruptions—events.

You also say that efforts to ensure reliability and resilience during extreme weather should focus largely on the distribution system rather than on any particular type of generation system.

Can you briefly discuss some of the issues learned this historic hurricane season regarding reliability and resilience issues?

Also, can you explain why policymakers should be looking at low-carbon resources and focus on distribution rather than sources of generation?

Mr. MOORE. Certainly. First of all, distribution system failures represent far and away the highest number of outages that cause blackouts in the country.

There is no—absolutely positively no question about that, and that if you can't deliver power from any resource to the customer it's just as good as no power at all. So that's number one.

And number two, as I implied, reducing the carbon—reducing carbon pollution reduces the risk of the high-intensity types of events that we have seen like the hurricanes last year.

Mr. RUSH. Ms. Speakes-Backman, yesterday Bloomberg reported that Sonnen, a generation—a German, rather, energy storage company is planning to install 15 micro grids in Puerto Rico in order to provide electricity to emergency relief centers.

Additionally, it is reported that Tesla, Incorporated will be sending hundreds of its overall power wall battery systems, and Sonoma, Puerto Rico's largest rooftop solar provider, plans to install batteries to complement its system. We have been told that it will take months to fully restore the island's electricity grid.

But in the meantime, can you discuss how we might utilize these small CO micro grids systems which can be installed quickly to restore power to a few buildings at a time that will help power hospitals, fire stations, relief shelters, and other emergency shelters during these most difficult times?

Ms. SPEAKES-BACKMAN. Thank you, sir, for the question, and I believe, sir, that you have the answer. You gave it in your question and I appreciate that.

Solar plus storage and storage plus many resources, as a matter of fact, depending on the location, especially if you've got distributed energy resources, can be a holdover, if you will, while you rebuild the grid to a more resilient phase.

And so this is why we have been cooperating and collaborating with SEIA. Just recently, on Friday and then on Monday, both SEIA and the Energy Storage Association announced a joint effort to request members supply and donate their resources, donate their expertise, and donate their dollars to support the efforts in Puerto Rico, to build micro grids of solar and storage to get us through this difficult time.

Mr. RUSH. Do you think that the Department of Energy is—could do more in terms of helping to encourage and assist in these micro grid efforts?

Ms. SPEAKES-BACKMAN. Sir, I think that the Department of Energy has continued to serve as an excellent resource for us in research and in working to commercialize batteries for storage.

I think, certainly, there are always things that we can do more to help—to help understand the applications that can be made and help to extend the duration periods of storage.

Mr. RUSH. So do you also feel as though these micro grid systems are something that we should seriously consider in terms of the future?

Ms. SPEAKES-BACKMAN. Absolutely. It meets many of the requirements that were laid out in the DOE staff report for resilience beyond fuel—beyond fuel supply.

So the ability not only to withstand external forces, whether they be weather or other external forces of calamitous events but also with respect to bringing the grid back on and to work within small communities to become islands of refuge, if you will, to be able to supply consumers with the refrigeration for their medicines, for their food, to be able to charge your batteries for your phone and your appliances and your computer to communicate with loved ones.

It's a very important aspect of reliability and resilience both.

Mr. RUSH. Mr. Chairman, I yield back.

Mr. UPTON. Thank you.

The Chair would recognize for 5 minutes the gentleman from West Virginia, Mr. McKinley.

Mr. MCKINLEY. Thank you, Mr. Chairman. Ms. Speakes, let me just start with you. Thank you for making the definition of reliability. I think so many on the panel have played around with that word.

They use it to fit their definition. Yours was very specific and I appreciate that. Others used it for their own purpose in their definition.

Mr. Wright, I got to you. My concern is shared with you and that is if we—and as we proceed with the tax reform, one of the concerns is that the tax credit for hydroelectricity at 1.8 cents—I think it goes up to nearly three quarters of a million dollars per plant to be able to subsidize that—I am concerned that that type of tax credit could be lost with that.

So we are going to be spending some time on research and make sure that we have those reliability on that. So thank you for bringing that as your point, because I've seen several in West Virginia located there.

Third is on gas reliability. I am, obviously, sitting in the center of the Utica-Marcellus. We are big proponents of it. There are three power plants that are considered in West Virginia to be open.

But my concern has been, and we have been talking again about this tax credit, is how we can do more research into making sure that the gas is the reliable source that Ms. Speakes was talking about because we have had too many outages with gas.

We want it to be—I can see the tremendous future using gas as a source. But when we see that we have had nearly—from 2014 to the first quarter of this year, there were 4,000 outages with gas because of the lack of supply—4,000 times that they've had to shut down, not the least of which came out through the polar vortex.

But I think we can—with research and the R&D we can salvage a lot more of that and bring it more in line. Because in my frame of mind, where I am coming from, nuclear is the most dependable, and I would say gas—excuse me, coal would be the next and then we would get into some of the others—fall down through that.

I want to bring gas up to a much more dependable source. But we have got to do the research to make sure that we can get that so that we don't have these outages.

And the last I want to turn to is Mr. Bailey. We had—Gerry Cauley was here, the CEO of NERC, and he testified here before one of our hearings that, quote, "Markets should review the economic and market factors driving base load generation into early retirement."

Now, that, I think, is the crux of much of this. Are we moving too fast into this arena when we've—about national security when we don't have power?

We can all talk about—we have all got our talking points about what happened during the polar vortex and we saw the numbers of plants shut down. Twenty-two percent of PJM shut down that.

So back on what NERC has been challenged—what FERC has been challenged to do following along what NERC has talked about, is this—if we are going to be serious in Congress about fuel security, don't you think this concept that has been proposed by DOE and over to FERC—is that a reasonable approach that they should be taking?

Mr. BAILEY. Mr. McKinley, so right now we are facing the prospect or likelihood of another 40,000 megawatts of coal retirements over the near horizon.

We have had 60,000 in the past. We face another 40,000. We agree with DOE that the markets are distorted. Now, there are a couple things that could be done and they are not mutually exclusive.

One, you could take the approach of DOE to address merchant generation. That's about 60,000-something megawatts as a coal fleet that would be affected—we are guessing right now—an educated guess—that could benefit from this.

There is a large part of the coal fleet that's not covered that serves wholesale electricity markets. It's not merchant generation.

So we have, in effect—I am trying to simplify this—we have a DOE rule that helps merchant coal and nuclear. There are other market reforms that could be undertaken to help those other fuel-secure coal-fired generating units.

The problem we have and the reason DOE set an aggressive schedule—and I'll come back to my non-answer to Chairman Upton earlier—is that we have talked to a couple of the grid operators that have the most coal-fired generation in their regions and we simply asked them how long it would take them to undertake market reforms—for market reforms that would help base load generation.

One of them told us 2 years. The other one told us 3 years. The one who told us 2 years said no, the guy who said 3 years is probably right.

So we do need to have a sense of urgency about this. Ms. Korsnick spoke to it, and I would say the same thing also.

Mr. MCKINLEY. Yield back.

Mr. OLSON [presiding]. Gentleman's time has expired.

The Chair now calls upon the gentleman from Saratoga Springs, New York, Mr. Tonko, for 5 minutes.

Mr. TONKO. Thank you, Mr. Chair.

Thank you to the witnesses also for the insightful testimony this afternoon.

Mr. Moore, your testimony noted that electrical distribution systems are responsible for over 90 percent of total electric power interruptions.

You're sharing the panel with a number of generation resources. Rather than picking winners and losers in generation, can more be done to harden distribution and transmission infrastructure?

Mr. MOORE. I think you—yes, I think utilities, especially in New York in the wake of Sandy and starting in Florida a few years ago started to do exactly that kind of hardening and those are the kinds of utility-focused actions that can be done outside of market design.

PJM actually developed some generation-specific, I would call them, hardening or resilience standards after the polar vortex that weren't embedded in the markets though had some common sense ideas like making sure your burners worked in the coal—for the gas plants and things like that—winter preparation.

So those are the kinds of things that I think customers on the ground would actually, you know, see fast and immediate benefits and would—actually could be done at relatively low cost. I think we can't forget the consumer in all this.

What we want to make sure is that we are not gold-plating the system in different ways. But we—I think some—I think utilities do recognize that our distribution system needs, you know, continuous improvement.

Mr. TONKO. Thank you.

And Mr. Kiernan and Mr. Mansour, do you agree that there are reliability benefits that can be gained through additional transmission estimates?

Mr. KIERNAN. I think that's a great question. Yes, transmission absolutely will improve reliability on the grid, resilience on the grid and, frankly, I think supports, you know, virtually all of our sources of electricity.

So it just makes sense to figure out ways to enhance and strengthen and extend our transmission grid for the benefits of the grid and to benefit, frankly, for us to be able to compete in providing low-cost reliable resilient electricity.

Mr. MANSOUR. We agree, Mr. Tonko. Absolutely. The more transmission—reliable transmission that you have in place gives you a range of possibilities to reel in power from various different sources and uses the diversity of fuel that we already have on the grid to the greatest extent possible.

And to answer to your other question on the distribution grid, we feel distributed generation from solar on rooftops is, obviously, a very positive benefit and provides a lot of that hardening, and when you marry it with storage either in a person's home or in their hardware store or in their Wal-Mart, it certainly does increase the ability of the distribution grid to maintain that kind of services.

Mr. TONKO. Thank you. The R Street Institute's response to last week's DOE notice of proposed rulemaking seems to agree with that sentiment. They say, and I quote, "A resiliency initiative should prioritize mitigating transmission and distribution damage and accelerating restoration."

Mr. Moore, R Street also suggests that DOE's proposal seeks to take emergency action on, at best, a low to medium level resiliency issue. Do you agree?

Mr. MOORE. I think that it is nowhere near the crisis that some parties have portrayed it to be. So yes, I generally agree that there are other things we can do like that transmission integration that would go a lot further towards improving the resiliency grid.

Mr. TONKO. Is DOE's proposed rule likely to raise cost to consumers without commensurate resiliency benefits?

Mr. MOORE. Sure, so far as I can tell, because it's very hard to predict the full extent of the costs, but our initial calculations say that at least $15 billion a year just from the operating and maintenance costs reflected in the units that could be covered by the rule.

That doesn't include the higher rates of return and—return on equity, excuse me—and other things and the additional higher market prices that we would have.

So I think a lot of work is going to be gone—is going to be put into figuring exactly how bad this would be for the consumer.

Mr. TONKO. Thank you. And much of the discussion today has focused on reliability and resiliency. But I want to bring up another important consideration.

I believe that a modernized grid must also be flexible. Flexibility allows for rapid response and smooth integration of variable resources.

So Mr. Durbin and Ms. Speakes-Backman, can you explain why we should not be overlooking flexibility and how does gas generation and storage's flexibility reinforce grid reliability and resiliency?

Mr. DURBIN. Mr. Tonko, if I could, I think—because I laid it out in the written testimony as well—it's one of the higher-valued attributes that natural gas brings to the table here and the flexibility to be able to provide that, that quick ramping flexibility, being able to follow a load, being able—you know, as variable sources come in, on and off of the grid, you know, a natural gas plant can be up and running in minutes rather than in hours or days.

So, again, I think you can't overlook the need for flexibility as the grid is now integrating additional types of generation sources and technology.

Mr. TONKO. Ms. Speakes-Backman, please.

Ms. SPEAKES-BACKMAN. Yes. On the—on the side of resilience, certainly, there is frequency response. There is micro grid islanding. There is black start service so that the centralized generation can come up.

And storage operates from zero to 100 percent in milliseconds and so it's able not only to provide resilience in the—in times of major outages but it's also able to ride through regular normal operations of frequency regulation.

The important thing to note, though, is there is multiple attributes to resiliency. So I could list those out—they are in my testimony—but it's important that they all be accounted for, not just one part of resiliency because, for example, let's say we do have all the 90-day—90-day fuel source on hand.

If transmission and distribution is unavailable that's not helpful. You can't get the power to people, and so you need a more distributed resource in that time.

The whole point, frankly, of resiliency is to plan for the unexpected. And so you have to have multiple solutions available and online and ready to react regardless of what you think the solution—what you think the problem is going to be.

Mr. TONKO. Thank you.

Mr. Chair, thank you for generous time.

Mr. OLSON. Gentleman's time is expired.

The Chair now calls upon the chairman of the full committee, Mr. Walden, for 5 minutes.

Mr. WALDEN. Thank you very much, Mr. Chairman.

I want to welcome our panelists. Mr. Wright, good to see you again in this capacity.

Last week, I explored the panel of witness—I asked them whether the wholesale power markets were working to respond to and engage changes in consumer behavior driven by new technologies and other lower cost generation options.

And the answer from most of the panel was to embrace competitive markets and to ensure that the markets do not have a technology bias.

So this week, I want to ask the same question of this distinguished panel. I understand the DOE issued an order on Friday on reliability and resiliency that is certainly helping to get the conversation started and one which we will be actively overseeing.

But I also understand how complicated these issues are and we shouldn't consider any one issue in a vacuum. There are market forces, economics at play as well as consumer preferences, new technology, jobs, subsidies, regulations affecting environmental externalities and carbon and regionally preferred resources.

So is reliability the only attribute not getting properly valued in these markets and, hypothetically—let me underscore, hypothetically, if we were able to design the wholesale electricity markets fresh from a blank sheet of paper, what would you recommend?

Who would like to start that? And then I just want to go down the panel. It's the only question I have for you today. Who wants to tackle that first? I am going to get to all of you so——

Mr. DURBIN. Mr. Walden, I'll go ahead and start.

Mr. WALDEN. Thank you.

Mr. DURBIN. Again, with a clean sheet of paper, I think we still need to look at what is it that's brought the value of the grid we have today.

Mr. WALDEN. Right.

Mr. DURBIN. I think we do have a very—an effective and efficient grid certainly in need of improvement. But I think we can't lose sight of the fact that we certainly look in the last, you know, 8 to

10 years—some of the benefits that we are really seeing, certainly, from the consumer price perspective.

So consumer benefits or the flexibility of attributes that we just talked about before, that's being driven by market forces. You know, I understand that, you know, natural gas——

Mr. WALDEN. We also have State regulation coming in. You've got subsidies involved in the markets. I am not saying that any of that's bad but——

Mr. DURBIN. No question. No, I am not——

Mr. WALDEN [continuing]. Things are changing.

Mr. DURBIN. I am not denying that there are—there are other forces that I think those are some areas we need—we need to look at and see are they distorting, you know, the market.

But I think, you know, certainly from a natural gas perspective the fact that we've had market forces allow natural gas——

Mr. WALDEN. Right. Enormous change.

Mr. DURBIN [continuing]. To play a much bigger part, and wholesale prices dropped by 50 percent in PJM. So I think more than anything else that's got to be the focus to allow for market-driven fuel neutral policies, going forward.

Mr. WALDEN. All right. I've only got 2 minutes for all of you to respond, so to the extent you can. And if you have other thoughts past this, please get them to me.

Yes, sir.

Mr. KIERNAN. I'll jump in. Tom Kiernan, American Wind Energy—the process I would suggest, first, trust the experts—FERC and NERC and the RTOs—to establish the specific reliability and resilient services as opposed to other bodies or DOE saying, here's the fuel source we prefer.

Let the experts pick the exact services and then allow us to compete for it, and the reason being, obviously, technologies are moving forward. Each of our technologies are advancing, and wind a number of years ago might not have been able to compete well for some technology, but right now, I think, we are the best——

Mr. WALDEN. Very competitive.

Mr. KIERNAN [continuing]. At disturbance ride-through capability because of our power electronics. And you want the market to be rewarded for those innovations and advancements. So trust the experts and allow competition.

Mr. WALDEN. Good. And I know when Mr. Wright was in a previous position we talked about the ebbs and flows of wind energy in the Northwest, where a thousand megawatts within an hour could come and go, and so then how do you balance that out and make the grid work.

So we heard last week battery storage didn't count in one RTO because it didn't have a flywheel. I mean, so we've got some legacy regulation to deal with.

Mr. Wright, do you have a comment on how we might do this——

Mr. WRIGHT. Specifically, to your question, first of all, I want to strongly endorse technology neutral. I think that is the key.

And then the question is what are the attributes that we want out of our power system. If we want reliability then we would go through the characteristics that are necessary—the services and products that are necessary in order to produce reliability and then let's make sure that we are providing value associated with that.

If we want environmental attributes out of our power system then we should be clear about what are those environmental attributes that we want out of it and then make sure that we have incentives associated with that.

That clarity around the outcome that we want would be the most useful thing that we could do in terms of better defining what will produce the outcome that consumers want.

Ms. SPEAKES-BACKMAN. Hi. I would just like to underscore what Mr. Wright said in that if we focus on the performance rather than the technology I think we can get there a little bit faster.

The FERC is—has a couple of rulemakings that are working toward looking at resilience. States are doing some work but I'll tell you, there is a big—there is a big difference between when we talk about the difference between reliability and resilience.

Because at the State level, as a former regulator I can tell you we had lots of cost-effectiveness training and cost-effectiveness tests to ensure reliability but not on the resilience. There were always the out clauses for those major storms.

Well, these major storms are happening more—more often and with more severity. And the tools aren't necessarily there at the State level to be able to value that.

Mr. WALDEN. Yes, sir.

Mr. MOORE. Sure. Yes, technology neutral, performance focused—I think FERC has done a very good job of recognizing regional variations and so that needs to continue to occur.

Clearly, I think energy markets have to—have to move beyond just fuel-based pricing and what we are doing now, I think, you know, focus more on congestion pricing as a bigger component of this and move away from a one-size-fits-all capacity market design.

I am really concerned about the money we are putting into capacity markets. Do we need to put all that money into that market? Can we do something else?

And last, just aggregate—smaller resources need to be able to participate in the market now. We have many more resources. It doesn't do anyone any good if they've got a nest thermostat or a smart meter if they can't access the markets shaping the price for the day.

Mr. WALDEN. All right. I know I am way over my time, but this is an important topic, obviously, for the committee. The chairman, the vice chairman, the staff have done a great job, I think, teeing up these issues as we look at the future of the electricity grid. And so we very much value your input.

And with that, Mr. Chairman, I yield back.

Mr. OLSON. The chairman of the full committee is never out of time. You always yield back. [Laughter.]

Chairman calls——

Mr. WALDEN. I've come a long way since I was Mr. Wright's driver, but we will explain that later.

Mr. OLSON. The Chair now calls upon the gentleman from Iowa, Mr. Loebsack, for 5 minutes.

Mr. LOEBSACK. Thank you, Mr. Chair.

I am very proud of my State for a lot of reasons, but Mr. Kiernan knows particularly wind, but I'll get to that in a second.

You know, actually Iowa is quite varied in terms of the sources of power that we have. We saw built not that long ago a natural gas plant. We, of course, have a lot of coal. We are exploding on the solar front.

I think we have tremendous potential for hydropower, especially in small streams and small rivers if we can get there at some point. I think they have tremendous potential.

But, clearly, I am very proud of Iowa's wind energy story and its place as a national leader in wind energy production.

And Mr. Kiernan knows it very well—he mentioned Iowa and Kansas a little bit earlier. My wife and I actually took a little bit of time away, about a week in August, and we drove up through northwest Iowa.

I can see some of the old lattice-style turbines. They are not very pretty, actually, compared to the newer ones. But and then we went to South Dakota and North Dakota and just saw the tremendous growth in wind energy up in those two States as well.

I have been fighting for a strong wind energy sector in my State since I've been in Congress. I think it's—not, again, to take away from the other sources of energy but, you know, it's cost effective.

It's been—it's been a good cost-effective source of energy in Iowa and creates great jobs, continues to—we continue to work for job growth in this sector. I just think it's real important.

We are upwards of 36, 37 percent of our electricity in Iowa generated by wind. Again, we are growing in these other—in solar in particular as well.

Well, I really only have one or two questions at most, and for Mr. Kiernan, when it comes to reliability, we have seen this tremendous growth in Iowa.

Have there been particular problems in Iowa when it comes to reliability and other States as well where we have seen this tremendous growth in wind energy?

Mr. KIERNAN. Well, thank you for the question. But first, also thank you for your leadership. You've been an extraordinary champion out there for all different sources but very much for wind and we appreciate that.

Mr. LOEBSACK. By the way, I forgot—we have a nuclear power plant at Palo too. I forgot about that.

Ms. KORSNICK.: Thank you for that honorable mention.

Mr. LOEBSACK. Sorry about that. It's not my district anymore. That's why I overlooked it. I apologize.

Mr. KIERNAN. But as we are 36 and well on the way to 40 percent in Iowa, there have not been any reliability concerns. And as I mentioned earlier with our newer technology that a lot of folks may not be aware of, we are able to provide most of the essential reliability services. So we have not had a problem on that front at all and I think the grid operators speak to that on a regular basis and I believe Mr. Cauley from NERC last week spoke to that as well. So wind is a very reliable part of a resilient grid and we are quite proud of that.

Mr. LOEBSACK. And that was my next question about the grid operators, and there hasn't been any particular issues at this point?

Mr. KIERNAN. Not that I am aware of, and actually grid operators, whether it's PJM, SPP, but also DOE's NREL have done studies showing that—NREL came out with a study that we could do well over 50 percent renewable without any issues.

PJM had 35 percent wind energy in one study and then extended it up to 80 percent in another study. So all these studies are showing that we keep blowing past these artificial ceilings people think for wind or wind and solar.

We are just—because of the innovation of America, we are just blowing past any perceived barriers and doing it reliably and, frankly, cost effectively for consumers.

As you mentioned, in Iowa and other States, the costs have been flat or coming down as we have added cost-effective wind energy on the grid.

Mr. LOEBSACK. Great. That's all I have. Thank you very much, and I will yield back the remainder of my time. Thank you, Mr. Chair.

Mr. OLSON. Gentleman yields back. The Chair now calls upon the gentleman from Illinois, Mr. Shimkus, for 5 minutes.

Mr. SHIMKUS. Thank you, Mr. Chairman. Thanks for you all being here.

So I am listening and the question is why are we here—what's brought us to this time. Everyrone has mentioned reliability, resilience, flexibility as a key component.

But we have also had a tremendously changing market from not just historically of regional monopolies in States. Mr. Moore, you mentioned Illinois. We went to competition.

But we also had a FERC that really allowed a changing of the transmission and the buying and selling across State lines without a change in the actual statutory language by the Federal Power Act.

Everybody would agree with that, right? I mean, we had a hearing last year with—talking about this and the Federal Power Act was so kind of vague it just—and some people were applauding that because it allowed this transformation that really did not have the guidelines of a legislative input.

And so now we have new entrants into the market, some—and they get more competitive but some were incentivized by public policy also, and we are trying to struggle with this new entity that we have and I think public policy folks—we just have to decide how do we keep focused as some of the commentaries were, what is our goals and our objectives in the future.

But I don't think—I don't think we should dismiss and in essence maybe penalize a major generation that helped get us here.

When I first became a Member of Congress we had three main generation capacities. We had coal, we had nuclear, and we had hydro. Natural gas was too high and wind and solar wasn't—wasn't there yet. Wasn't in the competitive world.

So now, again, I think our biggest challenge is making a definition without—everybody knows where I stand. A major nuclear power State. We do have some wind. We have big coal generation.

But I find even in this discussion between the DOE's language, PJM's language, NERC language is a difference in what I used to understand is the term of base load, because my base load debate came out of regional monopolies serving at set area and what was the demand and who could provide that.

Now base load has some different definitions based upon who you're asking. So whether that's stacked generation or—so I am going to do what Chairman Walden did, go down the table real quick.

What is your definition of base load or is there a definition of base load and should there be a definition of base load?

Mr. DURBIN.

Mr. DURBIN. I would suggest that the traditional definition of base load is no longer relevant. I think base load—you know, the traditional base load plants that we have there are—continue and will continue to provide an important source to the electric grid.

But I think the grid has now moved to a place because we have now got such advances in technology, that we have got these more flexible, you know, sources there. We have got—got the, you know, both from a performance, cost, and, you know——

Mr. SHIMKUS. Let's go quickly. So I want to get down. So——

Mr. DURBIN. So my answer is I don't think the traditional definition—it no longer—we have got to stay focused on the attributes that are necessary to make the grid reliable.

Mr. SHIMKUS. Mr. Bailey?

Mr. BAILEY. You know, the material I've read recently says, you know, the term base load is outmoded. Maybe the term is. Maybe it isn't.

To me, the discussion now is, you know, about reliability, resilience, flexibility, that sort of thing. So I've personally sort of moved away from it. But it's a good——

Mr. SHIMKUS. Let me just—we won't ever get through everybody so let me just say——

Ms. KORSNICK. I am ready. I am ready.

Mr. SHIMKUS [continuing]. In a regional transmission organization they had—they still have a base load that they have to, in essence, the demand that they have to meet. Is that true?

Ms. KORSNICK. That's true.

Mr. SHIMKUS. An RTO?

Ms. KORSNICK. Yes.

Mr. SHIMKUS. And do we or should—and that was from—Maria answered that—and should we—is there—part of the elephant in the room is do you incentivize those who can provide big percentages of a base load in an RTO? Maria.

Ms. KORSNICK. Well, I go back to your first question on what's base load and let's say, you know, you can be there 7 days a week, 24 hours a day. Somebody needs to be there all the time and I think there is a, you know, a value for that base load power.

Mr. SHIMKUS. That's part of the discussion and debate and I am over my time. I've probably put more questions than I probably should have in the whole mix but that's what the hearing is for.

Thank you. I yield back.

Mr. OLSON. Thank you.

The Chair now calls upon the gentleman from California, Mr. McNerney, for 5 minutes.

Mr. MCNERNEY. Well, I thank the gentleman from Texas, and I want to thank the witnesses.

You know, it's interesting the different perspectives that you all are bringing to this. But I think one thing that was in common was that you all felt like the real solution is in true valuation of the different sources of power.

And I am wondering how would we go about achieving a true valuation. I know we'd want to have metrics defining resiliency that would work.

Mr. Moore, could you take a crack at that?

Mr. MOORE. Sure. FERC has already, you know, started down this road by creating technology-neutral markets for frequency response, inertia services, voltage support, and things like that—the whole range of ancillary services.

So there is already a track record. I think the work to be done is on what additional reliability or resiliency metrics we might need to do.

So I think there is a lot—there is more work to be done. I know that we are already transforming the grid in some places more than other in this country, you know, and doing fairly well.

So I think as new resources come into the market like energy storage, let's look at if there are barriers, as we have already heard, that might exist in some markets.

I can just say that I have not heard one RTO, for example, say that we need a base load unit to meet reliability and resiliency needs of the future.

Mr. MCNERNEY. So it does require some Federal involvement then to get there?

Mr. MOORE. I think—I think FERC and the RTOs are looking at this, yes.

Mr. MCNERNEY. So if that were to come about, would the increased penetration of intermittent renewables cause reliability problems?

You can go ahead, Mr. Kiernan.

Mr. KIERNAN. If I can jump in. No. I mean, we have got wind and solar that are reliably being added to the grid. We do think base load is kind of an older concept but I will say some grid operators refer to wind as the new base load.

Base load is often—it used to be referred to as the lowest cost out there and, frankly, in many parts of the regions or the country, on an unsubsidized basis wind is the lowest cost source of new generation. So that's a way a number of folks are thinking about wind. It's just affordable.

Mr. MANSOUR. I would just use the example of California. Yesterday at noon, California got 45 percent of its electricity from renewable sources.

Now, that includes solar, wind, who are intermittent, but then some others who are not like geothermal and some others. But California, as you know, serves the sixth largest GDP in the world.

Mr. MCNERNEY. Well, I mean, that's the thing. The Nation has different characteristics and I think all of the different sorts of generation will be more preferable in different regions.

So, I mean, there is tremendous new technologies and entrepreneurs that are entering the market. I hear about them all the time on the Grid Innovation Caucus. Mr. Latta and I are cochairs of that caucus, by the way.

How will this impact the reliability of resilience and flexibility—this new technology and the new entrepreneurs that we are hearing from?

Mr. Moore? You're kind of the neutral—you're the only one that's really neutral here today.

Mr. MOORE. I'm trying to be as neutral as possible.

Mr. MCNERNEY. As possible.

Mr. MOORE. No, I think that innovation really is a driving force here, as you said, and that, you know, FERC's standard is just and reasonable rates without undue discrimination.

As someone has already said, it's a pretty general principle but it's been foundational and really important and it gives FERC and the RTOs the flexibility to change market rules to strike down barriers to new entry and that—and if they do so in a way that those resources and those new services can meet grid needs more affordably and cheaply, then so be it. That's what's beautiful about the FERC market design.

Mr. MCNERNEY. Would it be a good idea for Federal policies to encourage deployment of the new technologies.

Mr. MOORE. I think—I think we strongly encourage research and development in that area along with next-generation market designs.

I think NREL and the labs have done terrific work on exactly that kind of work in the past and I think to maintain our Nation's, you know, leading role in the next-generation modernized grid we need to keep the foot on the accelerator on those initiatives.

Mr. MCNERNEY. One of the technologies that I'd like to see a little more is carbon sequestration.

Mr. Bailey, could you address where we are, what the future looks like in terms of carbon sequestration?

Mr. BAILEY. Trying to think of a simple answer to this. You know, carbon capture sequestration is still under development. It is—it is still very important. The U.S. will probably need it at some point in time. The rest of the world, certainly, is going to need it longer term.

Obviously, we are going to continue work on fossil fuels. The last time I looked at the figures on carbon capture and sequestration was 2 or 3 years ago, and everyone knows that it is prohibitively expensive. We hope it will not be.

A new coal unit, for example, would be somewhere in the range of $2 billion, and adding carbon sequestration and storage to one, this is—this is probably badly out of date but it'll give you sort of a scale of magnitude—it was about another billion.

Now, that suggested we had a lot more work to do on carbon capture and sequestration.

Mr. MCNERNEY. Yes. I just want to finish by saying to my Republican colleagues please embrace carbon sequestration for your own good—for your own districts' goods.

With that I yield back.

Mr. OLSON. Gentleman yields back.

The Chair now sees the gentleman from Michigan showed up. The Chair calls upon Mr. Walberg for 5 minutes.

Mr. WALBERG. It's called—thank you, Mr. Chairman—it's called Michigan sequestration here.

Thanks to the panel for being here. It's important to continuation of the issue we look at for energy.

Mr. Wright, you may or may not know, but we have a fairly major pumped hydro storage facility in Michigan—in western Michigan, connected to CMS Energy from my district.

Interesting process for me to comprehend. How are pumped hydro storage facilities helping integrate intermittent forms of renewable energy into the grid?

Mr. WRIGHT. Mr. Walberg, I am familiar with that. I am actually a graduate of Central Michigan University and Farmington Hills Harrison High School. So from your area.

Mr. WALBERG. Hey.

Mr. WRIGHT. The pump storage makes huge contribution because what we are trying to do—there is really radical change happening to the operation of the electric power system today and we shouldn't underestimate the impacts of that change.

We can deal with those impacts if we have time, money, and foresight, and one of the ways that we deal with that is through finding ways to be able to take energy from times when it is being produced and it doesn't produce highest value for consumers and move it into periods when it does.

Pumped storage creates that capability to be able to move the energy in a time when it creates highest value.

Mr. WALBERG. I've been interested to watch that as I've learned more about that and absolutely correct, it is a way of in my mind, of producing something that would be produced naturally at many places with hydropower but using it in a way that makes sense to add to that as well and be creative in its usage. So thank you.

Ms. Korsnick, can you explain how onsite fuel contributes to the reliability of the electric grid?

Ms. KORSNICK. Yes, certainly. For a nuclear plant, for example, we put all the fuel that we need for 18 to 24 months in the—in the reactor core. So we are not depending on any sort of fuel delivery.

And so you can just imagine through what we just mentioned, on some of the recent hurricanes or any sort of catastrophic event you're assured that your fuel is there ready to go.

In the case of a nuclear reactor it's already in that core ready to produce the much-needed power any time that it's needed.

Mr. WALBERG. I think hardened is a good word that we need to remember relative to nuclear power. Nothing is hardened against everything, I suppose, but it's significantly hardened when we think about nuclear and I think of our plant, DTE Fermi plant sitting on Lake Erie. Fortunately, no tsunamis do we expect there.

But the hardening that's gone on is encouraging, plus, as you've talked about, the ability to store the necessary fuel to have the power.

Go and talk to us about nuclear power support of voltage control. How does it do that and, significantly, what do we see there?

Ms. KORSNICK. Certainly. I can actually reflect on my times as an operator in the control room at a nuclear plant and, you know, you'd get a call from the——

Mr. WALBERG. I wondered why you were glowing. [Laughter.]

Bad joke. Bad joke.

Ms. KORSNICK. You'd get a call from the transmission operator, and just based on the fact that the power plant produces the power that it does, you have the ability to adjust voltage in support of the grid and you also can adjust what's called reactive power in support of the grid.

And so, you know, this is as a result of the size of the power plant and one of the attributes, quite frankly, that nuclear brings to the grid is these ancillary services.

Mr. WALBERG. Thank you.

Mr. Chairman, I yield back.

Mr. OLSON. The gentleman yields back.

The Chair calls upon the gentleman from Texas, Mr. Green, for 5 minutes.

Mr. GREEN. Thank you, Mr. Chairman, and I want to thank both the chairman and the ranking member for holding the hearing today.

Grid reliability and resiliency is something we often take for granted. With Secretary Perry's directive to FERC for a proposed rulemaking for a grid resiliency pricing rule, this issue deserves a lot of discussion. And when Secretary Perry was Governor of Texas that's when we expanded our wind power dramatically and it's part of our grid in ERCOT.

I am afraid the latest move may artificially tip the scale and that's something, I think when he comes before our committee we need to talk about.

The secretary has issued a directive to combat what he calls immediate dangers. In the North American Electric Reliability Corp. report from earlier this year made no claim of a grid in crisis from the retirement of coal power plants.

The CEO of NERC testified in June that the state of reliability in North America remains strong and the trend line shows continuing improvement year upon year.

In its 2017 report, NERC did highlight that transition to gas and renewable generation requires new strategy to ensure voltage control, power ramping capabilities, and frequency support.

Storage capabilities are key as those new fuel sources expand their share of the power generation. I want to ask the panel in terms of these newer fuel sources of gas, solar, and wind: What changes have we seen in terms of storage capabilities in the last few years, and where is the industry going, and how does this address the issue of reliability and resiliency when it comes to fuel sources?

We will start at this end, if you could—as brief as you can.

Mr. DURBIN. Thank you. Thank you for the question.

Mr. GREEN. I am not a Senator. They only give me 5 minutes. [Laughter.]

Mr. DURBIN. From the natural gas standpoint, one of the strengths that it brings is the robust nature of the entire system. So you've got geographic diversity as far as where we are producing and how it's transported around the country—300,000 miles of pipe.

You know, storage facilities all around the country so you package all that together with the—with the—and then delivering it to the—you know, to the end user—to the generator. You've got a powerful portfolio that they can then pull from to provide that reliability.

Mr. GREEN. Anybody else? Yes.

Mr. KIERNAN. Just from wind's perspective, I mean, we welcome storage on the grid. Obviously, it brings some services that are helpful to the grid.

But to be clear, wind energy does not need storage per se because the grid itself in a way is one large storage system in which the grid operators are compensating one for another. You know, if wind is a little low, they kick in more gas, et cetera. So we welcome storage but it's not needed to add more wind.

Ms. SPEAKES-BACKMAN. I will just add and echo that, that energy storage on the grid it likes all resources from solar and wind and hydropower to natural gas, coal, nuclear. It spans the entire spectrum of energy.

It addresses short term in fluctuations and it addresses long-term issues of transitioning of the grid. For example, the ability to put storage in a specific location to offset peak periods during the times of transmission and distribution upgrades or to even offset the costs of those upgrades.

And so I would say that while storage can enable more generation from variable resources, it also supports the grid in those so-called base load resources as well.

Mr. GREEN. Mr. Durbin, one of the criticisms of gas-fired electrical generators, especially in the Northeast, that they often have trouble getting deliveries of the commodity during cold months and due to pipeline bottlenecks and being put in line behind gas providers for pipeline capacity.

Are there fixes to the existing market rules that would increase your liability when it comes to natural gas or do you see an infrastructure problem?

Someday we may get a pipeline across New York to serve the Northeast. But I think Congress may need to get into that business—that States can't just stop someone from going across.

But anyway, is there something we can do with that problem?

Mr. DURBIN. Yes. First of all, I completely agree with you about New York and happy to help in any way we can.

But I think when you're talking about the Northeast it is both. Yes, there is a constriction—there is not enough infrastructure in place. I mean, need more pipelines to serve the demand in the Northeast region. There is a reason why they pay more than 50 percent more for electricity than any other region of the country.

Having said that, there are market fixes that can be made and you have generators who, in large part, you know, have interruptible contracts, you know, for their gas. The fact is nobody—even during the polar vortex, no one who had a firm contract for gas didn't get their gas. Everyone got their gas.

And so, you know, any outages we referred to was more—it was contractual outages because they didn't have—you know, they had interruptible contracts. But I do think that there are things that could be done to allow for generators to enter into.

Sometimes they are not allowed to enter into those types of contracts. The answer is yes, there are solutions.

Mr. GREEN. And I know I am out of time.

But, Mr. Chairman, let me just mention, when we had Hurricane Harvey coming in, a lot of our problems were there but the nuclear power plant southwest of Houston stayed and—stayed and continued producing electricity.

So, I mean, that's why we need all the above and have a market that has many different sources.

Thank you, Mr. Chairman.

Mr. OLSON. Gentleman's time has expired.

The Chair now calls upon the gentleman from Illinois, Mr. Kinzinger, for 5 minutes.

Mr. KINZINGER. Well, thank you, Mr. Chairman, and I want to thank everybody for being here and thank you for your time. The hearing is particularly timely.

This question I am going to actually ask to Ms. Korsnick. As I mentioned, the hearing is timely because DOE filed a notice of proposed rulemaking for FERC to accurately compensate generation resources like nuclear, which is extremely important in my district and in my State necessary to maintain reliability and resiliency.

The secretary cited events like the 2014 polar vortex, which, in Illinois and throughout PJM, could have been much worse if it was not for our nuclear fleet.

What challenges does the nuclear industry face when it comes to participation in wholesale electricity markets?

Ms. KORSNICK. One of the challenges, for example, and it actually occurs in your States—some of the other technologies make money besides just from what they get from the market, so, say, from tax credits, for example. And as a result of that, they are interested in putting their power on the grid and it can even be at a low price.

It could be zero. It could be even less than zero, and they are still going to make money because they are going to get that tax credit.

So I think we are all a fan of fair markets. We would just share that the markets in fact are not fair today and that's an example in this case where it's not fair to both sides and in this case when the prices go negative and the nuclear plant is operating, essentially they have to pay the grid operator to take their power.

Mr. KINZINGER. And let me ask you, if this DOE's rulemaking is put into place, if it's implemented, how would that affect the existing nuclear generation fleet?

And let me—I guess I'll follow on—if the markets aren't reformed, do you anticipate this trend of early plant retirements will continue and how would that affect grid reliability?

Ms. KORSNICK. Absolutely. I'll take your second question first. But if this trend were to continue, yes, you will see more premature closures of nuclear plants and, again, from a nuclear plant perspective, once that decision is made to close that plant, that decision isn't reversed. Once people no longer are licensed, et cetera, and you start going through the decommissioning process, it's not something that you turn around and change.

So these decisions are once and done decisions, which is why we want to be very careful that as a nation we are not making some strategic decisions based on some market challenges that we will later regret.

And so, as you mentioned, the notice of proposed rulemaking from Secretary Perry, one of the things that it does is it recognizes some of the attributes that nuclear does bring to the market in the area of resiliency.

Specifically, they are focused on that 90-day fuel supply as one of the examples that they use for resiliency and some of the other ancillary services like voltage support, et cetera, that can be offered by a nuclear plant.

So it goes to valuing some of the attributes that nuclear is bringing to the market today that aren't being recognized.

So yes, it would be helpful.

Mr. KINZINGER. As well as carbon neutral, I think it's important to note.

In your testimony you discuss that China and Russia are aggressively working to export nuclear technology around the world. It's a big concern of mine. Can you discuss that effort and provide your perspective on how this could actually affect our national security?

Ms. KORSNICK. Absolutely. There is 58 reactors being built around the world today. Two-thirds of those are being built by Chinese and Russian design.

The Russians know very well what it is that you get when you build a reactor in somebody's country. You start a 100-year relationship with that country, by the time you design it, build it, operate it, and decommission it.

So they strategically look at the building of these facilities in terms of establishing that relationship, and if you look at the United States, quite frankly, as a result of us allowing our nuclear fleet to begin to atrophy, we are ceding our leadership at the national—at the international table, quite frankly, on nuclear issues.

That means we have less of a voice on operational excellence. That means we have less of a voice on nonproliferation issues, because all of that comes with the package, if you will, when we build American reactors around the world.

And so, quite frankly, we just need to look strategically at the messages that we are sending, and by shutting down our fleet at home it does not put us in a leadership role internationally and that affects our national security.

Mr. KINZINGER. Yes, and it's hard to take a leadership role when you have less skin in the game than your competitors I think is important to note.

So thank you all for being here. Thank you for participating and, Mr. Chairman, I'll yield back.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon the gentleman from Oregon, Mr. Schrader, for 5 minutes.

Mr. SCHRADER. Thank you, Mr. Chairman. I appreciate it very much. Just to preface my remarks, I am one of those all-of-the-above energy guys. I think that's an important—you have made that crystal clear, I think, in your testimony to not get locked in on just one source of energy.

Focusing a little bit on the hydro, if I may, with Mr. Wright. You know, some discussion about base load. I do want to make sure that we have—our lights go on, our heat work, or whatever as time goes on.

Seems like hydro is never talked about as base load. Could you give me your perspective on that?

Mr. WRIGHT. Sure. I think—I think base load actually is two components. It's a pricing component and it's an availability component.

So, historically, the lowest cost—lowest variable cost resource on the system operated as much as you could possibly operate it and those tend to be nuclear and coal plants, and it was also available all the time.

Now what we are finding with variable energy resources—those lowest variable cost resources tend to be solar, wind, and hydro—are all operating and we compete, candidly, for market share at the points when lows are low and then we also are operating as much as we can when loads are higher.

So what you really need is to be able to combine those two. You want the lowest cost resources operating but you want to make sure that you have the availability to meet all loads at all times.

And so it's going to take a new concept, I think, beyond—a new word, because the word that we've been using for our history in the electricity industry, the industry has changed too much——

Mr. SCHRADER. I know.

Mr. WRIGHT [continuing]. And we are going to have to come up with a new way to describe this.

Mr. SCHRADER. Could you also comment on long-term versus short-term focus on energy sources? You know, natural gas is a great resource—very low cost now, total disruptor in the market place putting pressure on our nuclear friends and, frankly, our hydro friends and I think pretty much everybody in the marketplace—coal, you name it.

So how do we—how do we deal with that sort of disruption? I know out in my neck of the woods in the Pacific Northwest people are talking about really having trouble coming to grips with long-term BPA contracts—our Bonneville Power Administration, which have historically been the backbone of energy up there.

What—get a comment maybe from Mr. Wright and maybe Mr. Durbin, if that's all right, or anyone else?

Mr. WRIGHT. First of all, we go through cycles in electricity markets. We went through cycles in the late 1990s when prices were really low and then we had the West Coast energy crisis and prices got really high.

And what we struggle with is how do we go through those periods when prices are low and make sure that we maintain the resources that will create best value for consumers for the longest period of time.

In this moment, I think what we are seeing is, as I said in my testimony, low energy prices and low capacity prices. To the extent that we can find ways to be able to think long term—what is it that will create best value for consumers over the long term both from a cost perspective and an environmental perspective and then we make sure that we have pricing regimes that will support those resources for the long term.

The difficulty that I see right now is that we—in the market formations that have been put together so far they are too focused on the short-term. You know, they are too much looking at the next couple of years as opposed to how do we be positioned for the longer term.

Mr. SCHRADER. Mr. Durbin?

Mr. DURBIN. Sure. I, certainly, acknowledge that natural gas and power generation has been a disruptive force. But I would also argue it's been a very positive disruptive force from consumer benefits on the costs of power, wholesale costs of 50 percent, environmental benefits, and emission reductions—you know, greater reliability to the system itself.

So do we—are there—are there ways that we can look at the market rules that are out there to catch up, if you will? Yes, absolutely. But I think, again, we have got to go back—go back and make sure that what's being valued are the reliability attributes and do that in a fuel-neutral and technology-neutral basis.

Mr. SCHRADER. All right. Very good.

Last question, if I may, I think, is large-scale battery storage. How closer are we to that? I mean, is it going to happen in the next year or two, or is it 10 years off, or can you give us a prediction, please?

Ms. SPEAKES-BACKMAN. It's happening today. It is happening today. There are—there is currently—the largest scale battery storage is 100 megawatts for 4 hours of riding through on the grid scale, and that's in North America.

Exponentially, our market is growing. It's grown at the grid scale level by 70 percent in the last eight—sorry, the costs of grid scale storage has gone down 70 percent in the last 8 years on the grid, and commercial and industrial level, those costs have gone down 80 percent in the last 2 years.

So we are seeing steep, steep drops in the cost. We are seeing States and Federal agencies begin to understand the valuation of storage, both on its supply into the grid and its taking off the grid of excess resources and beginning to consider, at least, being able to value that.

And so I say that that time is now. We are able to encourage more penetration of low and no-carbon resources. We are able to take additional power off the grid for those base load resources that are inflexible and can't ramp up and down very easily, thereby extending the life of those resources.

So I think this is happening now.

Mr. SCHRADER. Thank you very much, and I yield back, Mr. Chairman.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon the Texan with the patience of Job, the gentrifying Aggie from College Station, Texas, Mr. Flores, for 5 minutes.

Mr. FLORES. You've misstated the patience part.

But I am an all-of-the-above resilience and reliability guy. I just noticed my solar system at my house was producing 2½ times what I was consuming at this point in time. But then it just dropped offline because it got cloudy a few minutes ago.

So for you three at that end of the table, I am glad you're here.

Ms. SPEAKES-BACKMAN. You should have storage.

Mr. FLORES. I am working on it. That's the next. I am waiting for the exponential price decreases that you're talking about. But I plan to do that.

We have talked a lot today about reliability, resilience, emissions characteristics, inventory, and fuel on board. One of the things we haven't talked about too much is the land environmental impact of the different types of energy.

So I have a question for Mr. Durbin and Mr. Bailey and Ms. Korsnick about if you—if you could, and you can use whatever metric you want to, but if you have a, let's say, a typical 500-megawatt plant, how many acres does it take of your respective power sources vis-a-vis solar, vis-a-vis wind?

Do you all have those numbers off the top of your head? If you don't, just pass and we will go to the next one.

Mr. DURBIN. I don't have them with me. We do have them. I'd be happy to provide them for you.

Mr. FLORES. OK. All right. Mr. Bailey?

Mr. BAILEY. Pass.

Mr. FLORES. OK. Ms. Korsnick?

Ms. KORSNICK. I would just say, roughly, you know, a square mile is what you would need for—you said 500 megawatt. It could be a 1,000-megawatt——

Mr. FLORES. OK.

Ms. KORSNICK [continuing]. Nuclear plant. I guess wind and solar——

Mr. FLORES. So it—OK. What would it be for wind?

Mr. KIERNAN. If I can jump in——

Mr. FLORES. Sure.

Mr. KIERNAN [continuing]. It's interesting. For a wind farm it's actually less than 2 percent of the land is used for turbines and foundations. The rest is continued to be used for farming and ranching and other sources at the land—or other activities the landowner wants.

Mr. FLORES. It takes a certain footprint to make that work, though.

Mr. KIERNAN. But that is just 2 percent. The foundation or the access roads—you aggregate that all, it's still just 2 percent and cattle, they don't seem to mind, and the wheat does seem to grow. So it's a wonderful multiple use of the land.

Mr. FLORES. OK. How about the birds? OK. We will come back to that later. Go ahead.

Mr. KIERNAN. Happy to——

Mr. FLORES. No, go ahead, Mr. Mansour.

Mr. MANSOUR. From the standpoint of solar, you know, a 500-megawatt solar facility would probably be somewhere in the range of eight to nine square miles.

Mr. FLORES. OK.

Mr. MANSOUR. So it is taking up a lot of room. You'll see those bigger ones, though, on mostly public lands and they are lands that, for the most part, nobody else has any desire to use or, you know, either in the—now or in the future other than for——

Mr. FLORES. And I won't talk about batteries because, I mean—do you have a—you had an answer for that?

Ms. SPEAKES-BACKMAN. Yes, I do, actually.

Mr. FLORES. OK.

Ms. SPEAKES-BACKMAN. There is no direct air, water, or—air or water impacts and it's got a minimal footprint. You can put a 30-megawatt battery storage in the—in the space of a—spare space of a substation.

Mr. FLORES. OK. Very good.

Mr. MOORE. And, Mr. Flores, can I just add, I think I've got the proxy for energy efficiency at the meeting today and energy efficiency takes zero additional land resources.

Mr. FLORES. I like your answer. That's good. Yes. I've gone almost all LED in my home.

In terms of the—there's—we have talked a lot about resilience and reliability and one of the things that got my attention a few weeks ago is that there was a large-scale failure in eastern Australia because there was a weather disruption that knocked the wind offline.

They didn't have enough spinning reserves backed up. And so that implies to me that there is a relationship between the base load terminology that we have used and then also the other non-base-load power.

So my question for this, and I am going to ask this of our three base load folks, if I can, although I guess hydro is sort of base load from time to time—if you have one megawatt of base load, with your three technologies what would it—let me—if you have a megawatt of solar or wind, what does it take in terms of reserves to back that up in your three technologies for base load? No? You want to start first, Ms. Korsnick? Mr. Bailey? Mr. Durbin?

Mr. BAILEY. I should turn the mic on them. I think the capacity—you probably ought to ask solar and wind what the capacity factors are. But they are less than 50 percent, as I recall.

Mr. FLORES. OK. And then——

Mr. BAILEY. Maybe 30, 20 percent—something like that.

Mr. FLORES. OK. I have a question for—how many were against the FERC proposal, by a show of hands?

Mr. DURBIN. The the DOE proposal?

Mr. FLORES. The DOE. Excuse me. The DOE request of FERC. I am sorry. OK. Against. OK. All right.

And so you would essentially be against putting in pricing characteristics because of fuel resilient or fuel supply for resiliency purposes.

How do you feel about getting rid of all subsidies for all technologies to have a truly economically neutral technology solution? We will start with wind.

Mr. KIERNAN. I'm happy to address that. Thank you.

The production tax credit is being phased out, as you well know, and I am pleased to say the wind industry proposed that, supported that, and as we say, we kind of have tax reformed ourselves. So that's phasing out. We are good with that, and honestly, we do call on our colleagues let's level the playing field and not have subsidies across the board.

I would also, if I may—you mentioned birds earlier. It's actually only .03 percent of all human-caused bird deaths are wind turbines.

Mr. FLORES. OK. That's cool.

Mr. MANSOUR. With solar, again, we are in the same kind of situation. Not exactly the same ramp down for the investment tax credit but with the extension in 2015, you know, Congress gave us an extension with the ramp down in the out years. And our company is—nobody is excited about having their tax credit go down. But our companies are willing to go along with that.

I would say I think you'd be hard-pressed to find any of the technologies represented up here who haven't received some sort of help from the Federal Government since their inception with the possible exception of Energy Storage, which really deserves some.

Mr. FLORES. I am into spending R&D for the battery parts. So anyway, I've run out of time. I wish I could go longer. I yield back.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon the gentlelady from Florida, Ms. Castor, for 5 minutes.

Ms. CASTOR. Thank you, Mr. Olson, for yielding and thank you to all of the witnesses for a very interesting discussion. And at the outset, I want to say thank you to Mr. Rush for continuing to raise the important issue of rebuilding or building a new resilient modern grid in Puerto Rico. In the U.S. Virgin Islands we have a once in a lifetime opportunity to do so and I look forward to the bipartisan efforts to protect the taxpayer in the future from another catastrophe.

And I guess Chairman Upton kind of set the tone at the outset with his questions relating to the Department of Energy's notice of proposed rulemaking for their so-called grid resiliency pricing rule.

I'd say, first off, that the time frame set by the DOE is extraordinarily too short for such a transformative impactful type of shift in Federal policy that is going to impact all consumers across the country and all businesses, likely shifting huge costs onto the folks we represent at home. So that's—hopefully, smarter heads will prevail on that time frame.

And then—but to the heart of the matter, for the DOE to cite economic and national security as the guiding principle for this notice of proposed rulemaking really turns that on its head.

It's—especially looking at it now through the lens of the most destructive hurricane season that we have had probably in our lifetimes. Maybe Katrina standing alone.

Even Katrina standing alone probably will not rise to what we are going to have to do for the three hurricanes that have hit this year and the other extreme weather events.

What they have put forward at the Department of Energy is a policy for 50 years ago based on the fuel MECS of 50 years ago. It is not a policy for resiliency and modernization for 2017 and the changing energy mix that is out there.

And when they—when I hear the talk of costs, I always like to remind everyone, yes, they are the finite energy costs that we analyze.

But if you're a person in Texas or Florida or just about anywhere, what you're seeing right now—rising air conditioning costs because of higher temperatures, your flood insurance is going up, the emergency aid package that all taxpayers will pay, that's going to be a high-ticket item—property insurance, beach re-nourishment, property taxes, not even to mention the increased cost of carbon pollution.

So this is quite a misguided effort that they need to take back to the shop and work on it. And I'll give you one example. In the Tampa Bay area just last week the Tampa Electric Company, now owned by Emery, that has been primary—primarily natural gas but the Big Bend plant is a longstanding coal-fired power plant, they've just announced the largest investment in solar power in the history of the State of Florida.

The so-called Sunshine State—we are not quite there when it comes to solar power. They are able to do this because not just consumers are demanding it but it makes sense for their bottom line. This is what the market is telling them.

Solar is much more inexpensive now, and I think this is just going to be the first step. You're going to—Duke Energy has already said they are going to do this. Other utilities are going to do this.

But, Mr. Mansour, with a so-called resiliency pricing rule like this, don't you think if you're favoring certain fuel sources that's going to have a chilling effect on other low-carbon fuels of the future?

Mr. MANSOUR. Congresswoman Castor, we share your concern both with the timing—the speed with which this is going forward—and actually the intent in general.

We feel very strongly that the grid itself right now, yes, it needs improvement. Those improvements should come as a result of market forces that look at and value some attributes in the way that they should be. We think——

Ms. CASTOR. And this is in a State that does not have a renewable portfolio standard, no renewable goals. So there is not that argument either that we are tipping the scale somehow.

Mr. MANSOUR. And we share your concern with transfer of lots of money from ratepayers to basically subsidized certain types of generating capacity.

Ms. CASTOR. Mr. Moore, you've said that you anticipate this would be extraordinarily expensive for consumers and businesses, and you threw out a multibillion-dollar number.

Do you see the chilling effect, as well, and we will add in those costs, too?

Mr. MOORE. Sure. I see it in numerous ways and I think that to simply pick one attribute over all others and reward that one attribute without any evidence to back it up, those mean that is diverting, easily, billions of dollars a year directly and indirectly, chilling market design and, you know, taking away good dollars that could have been—you know, the consumers could have held on to those dollars.

Ms. CASTOR. So I would say that the true threat to resiliency is the Trump administration's allegiance to the policies and the fuel MECS of 50 years ago.

Clearly, they are favoring fuel sources that are less competitive today. This is going to cost consumers dearly. I cannot believe that in—while we are still recovering from hurricanes there is no mention of mitigating transmission or distribution damage in a resiliency rule or how we accelerate restoration after an extreme weather event.

So I trust that the comments to the DOE and FERC will reflect all of these concerns. Thank you, and I yield back.

Mr. OLSON. The gentlelady yields back.

The Chair now calls upon the gentleman from the Commonwealth of Virginia, Mr. Griffith, for 5 minutes.

Mr. GRIFFITH. Thank you very much, Mr. Chairman. I appreciate it greatly. I find some of the comments today somewhat interesting.

I, too, am an all-of-the-above kind of guy but, you know, let's take a look at history as we see it in reality as opposed to just with our particularly viewpoint.

I confess up front, my district has a lot of natural gas and a lot of coal. With that being said, Mr. Moore said we don't want to get into a situation where we have, you know, one administration coming in and then another administration coming in.

But in fairness, that's exactly what we have seen because the—if we would have gone to the market policy, say, 10 years ago that many have advocated today, wind and solar and even battery storage would be in a lot different position because the market kings would have been those forces that have recently been characterized as being 50 years old, and to now have those particular fuel sources castigated to the trash heap of history without recognizing the huge investments that our ratepayers have put into those and recognizing that that is at least for the next 10 or 15, maybe 20 years a big part of our grid reliability creates some interesting issues.

We are where we are. We need to move forward. I understand that. But it is nice to note that sometimes you have to look at history.

For example, the great State of Florida talks about air conditioning. You know, 125 years ago, before coal was discovered in my district, the people came to the mountains to get out of the heat, and they spent months in the summertime getting out of Richmond and Washington and coming to the mountains of Virginia.

It was a big economic source. We have shifted from that to coal and now we are shifting again. But I don't know that we should do it as rapidly as some people want without, I think, risking our reliability.

Mr. Bailey, I got to—I got to say, you know, I was listening. I wasn't in the room when you actually said it but I was listening on the TV as sometimes we want to do when we are trying to do five things at one time.

And could you tell me again those numbers? Seventy-two days I think I heard that we have—able to stockpile certain types of coal and 80 something for another kind. Could you go over that again? Because it was just nice to hear.

Mr. BAILEY. I would be pleased to. Over the past 5 years, average coal stockpile at a power plant has been 72 days for bituminous and 83 days for sub-bituminous.

Mr. GRIFFITH. Yes. Over—since you ask, over the last 9 years, the low has been a little over 40 days and the high has been a little over a hundred days.

So while there may be some difficulties with other things, you can put a lot of coal in the back 40 if you need it to be there for reliability purposes.

Mr. BAILEY. There is—there is a lot. Yes, sir.

Mr. GRIFFITH. Yes. I do appreciate that.

Look, we have got some interesting things going on. I am curious, Ms. Speakes-Backman, if you all consider from your industry standpoint pump storage hydro to be batteries, because that's kind of the way I've been looking at it, and we are looking at putting some of those, hopefully, into some abandoned coal mines to generate some economic development in our neck of the woods and store that.

They are even talking about using some renewable sources—wind or solar—to pump it up in the nonpeak periods and then have the water ready to flow down to the lower levels of the mine at the appropriate time when it's peak. Do you all consider that a part of your mission?

Ms. SPEAKES-BACKMAN. Absolutely. Absolutely, 100 percent.

You know, hydro is one of the early storage technologies. It helped to offtake the oversupply from base load resources back in the day when it was beginning to be installed.

So we absolutely consider storage as or hydro—pumped hydro storage as part of our storage infrastructure. Mr. Wright has represented the hydro storage industry quite well and so I focused on batteries today.

Mr. GRIFFITH. And I appreciate that very much and do appreciate Mr. Wright's testimony as well.

In closing, I have to say it's not politically necessarily a positive, but as a conservative Republican I am also a bird watcher. So I am concerned about wind killing birds.

I recognize that it may not be a huge percentage. Clean windows on big office buildings does a lot of damage to birds as well. But I once had a bill on that and tried to solve that problem at least for Federal buildings as we renovated as well.

But I do hope that the wind industry and the solar industry will recognize that we have some obligation to make sure we are not whacking or frying the birds as they go over or near our energy facilities.

Mr. KIERNAN. Thank you for bringing that up, and I very much share your concern as a former executive with New Hampshire Audubon.

I, as well, am out there birding on a regular basis and I will say the wind industry takes very seriously our strategy to reduce bird take.

And I appreciate the Department of Energy. Actually some of their grants have gone to helping advance new technologies that are being commercially tested as we speak.

So we are hopeful that we can take our low impact and make it even lower.

Mr. GRIFFITH. Thank you very much, and I yield.

Mr. MANSOUR. Let me just add, on behalf of the solar industry, we also work very hard to mitigate the impact on wildlife whether it is avian species or some of the terrestrial ones, as well.

So our companies spend tens and tens of millions of dollars per project to try to mitigate those kind of impacts.

Mr. GRIFFITH. And I appreciate that, and thank you very much and yield back.

Ms. SPEAKES-BACKMAN. For the record, we don't kill any birds. [Laughter.]

We are pretty good on that front, too.

Mr. OLSON. The gentleman yields back.

The Chair now calls upon himself for 40 minutes, 5 per witness. [Laughter.]

OK, you guys passed the test.

This is an important hearing, and that importance was reinforced this week by the Department of Energy's proposal to FERC on valuing base load generation.

But most importantly, it gives Texans like me a chance to do what we like best—brag about Texas. Unlike many States, Texas has a very diverse power grid.

We think we have the most diverse one in America. Mr. Durbin, natural gas is number-one for power production in Texas.

Mr. Bailey, it was coal until 2 years ago. Coal is number 2 very closely. Ms. Korsnick, we have Comanche Pass and south Texas, two nuclear plants. My colleague, Gene Green, mentioned about south Texas.

Harvey hit in Corpus Christi. The worst part of the hurricane is the northeast side. That part hit Bay City in south Texas. Not one blip of power lost, despite a category four hurricane hitting a nuclear reactor.

Also, we have exploding solar. Mr. Mansour, Army bases—Fort Hood and Fort Bliss, the biggest ones in the Army are now using solar to power the base. They actually export that to the power grid there locally.

We are number one, Mr. Kiernan, in wind power. Texas is number one for wind. And last spring, as you know, almost half of our power grid was supplied by wind power—one half for one day.

And back home in my district, a place called Thompsons, Texas, I wish Mr. McNerney was still here because we have what's called the Petro Nova Project. It's NRG's Parish Power Plant and this is a true carbon capture sequestration for enhanced oil recovery that works.

Working with a Japanese company, we have technology that grabs 98 percent of the CO2 coming from one coal generator. That's viable because about 65 miles southeast is an old oilfield. There is a pipeline that comes by.

So they grab that CO2, put it in that pipeline—like fracking fluid, repressurized. Hey, they are making money by carbon capture sequestration. But that's rare.

But this diversity does not make the coast immune to problems. In the winter of 2013, we had a big cold snap. Lost two of our coal generators. Had rolling brownouts and blackouts all across the State.

Some days there is not enough wind, and then during Hurricane Harvey, we had way too much wind. The turbines went offline. And these problems aren't hypothetical and they show that there is not one perfect energy source.

And my question just to the entire panel, I'd like to go down the line for the different sources here and I'd like you to describe what's the common cause of unplanned outages where you can't provide power and then talk about how you are addressing those issues.

Mr. Durbin, you're up. Natural gas.

Mr. DURBIN. Thank you for the question. As I mentioned to Mr. Green—as we talked about it, and Mr. McKinley had raised the issue of outages—for natural gas and power generation, any outage is being caused not by a lack of supply or a lack of availability but by contracts that—you know, they are interruptible contracts.

So these are all things that can be addressed, can be—can be resolved with the natural gas to continue to provide that reliable service.

Mr. OLSON. Mr. Bailey—coal, sir.

Mr. BAILEY. Yes, sir.

Well, we talked about the amount of fuel onsite at fuel plants. We think that makes the coal fleet very reliable and subject to very few outages, frankly.

Mr. OLSON. Ms. Korsnick, nuclear power, ma'am.

Ms. KORSNICK. As I stated, if you look at the nuclear fleet in the United States, we have had greater than a 90 percent capacity factor for 15 years. So I would say in general nuclear has fewer unplanned outages.

We do have a refueling outage every 18 to 24 months on our plants.

Mr. OLSON. Mr. Kiernan, wind power, sir.

Mr. KIERNAN. If I can start with a contextual observation. Gerry Cauley of NERC a week or two ago commented about the reliability on the grid is good and getting better.

So I just, first, want to observe that this is an important topic. But we don't have an urgent problem. We just need to work it.

As to wind, it's fascinating because we have wind turbines that are relatively small—1, 2, 3 megawatts—and they are geographically dispersed, while there might be a few that go down because the winds are too high in one part of Texas, there are a bunch in another part of Texas that are still rolling along.

So actually our geographic diversity gives us tremendous resiliency that we are adding to the grid.

Mr. OLSON. Mr. Wright, solar power, sir. I am sorry.

Mr. WRIGHT. Water.

Mr. OLSON. Water guy—hydro. That's not much for Texas but, please, what's your biggest challenges for the Nation?

Mr. WRIGHT. My colleagues from the large public power council.

So you have hydro power in Texas as well. The—what I would say is, look, anybody that has hydro resources, run them, son, as much as they can because it's the low-cost resource. It's the most reliable resource. It's the air emission-free resource.

The biggest challenge in the hydropower industry is that it's an aging fleet and we need to make investments in that fleet in order to make sure that we continue to be able to get the output from it.

Mr. OLSON. Mr. Mansour, finally.

Mr. MANSOUR. Yes, sir.

Mr. Chairman, I am going to totally ignore your question. But I am going to follow your lead by bragging on solar in Texas.

We got 1.6 gigawatts right now. We are going to go to another almost 5 gigawatts over the next 5 years, and a lot of that is because the way ERCOT and the Texas market is set up.

Mr. OLSON. Keep talking.

Mr. MANSOUR. Yes. I am not sure. I think it was Mr. Green that talked about some of the work that former Governor Perry did with the CREZ lines.

Yes, that incentivized a lot of wind. Basically, it was the classic build it and they will come. So, you know, the people of Texas put out I think it was $10 billion or more to build these CREZ lines or some—these transmission lines.

Wind was the first to respond because they were a little bit ahead of us. But solar is catching up and we already employ over 9,000 people in the State of Texas and we are going to be growing in your State.

Mr. OLSON. Ms. Speakes-Backman, concentration type stuff.

Ms. SPEAKES-BACKMAN. I love this question because we are here for reliability and resilience, and for all of these resources along the table.

In fact, Texas has quite a few batteries in place on the grid and just pointing that out. Duke has batteries providing frequency regulation. AEP has batteries that have extended the transmission and distribution life with another 20 megawatts being built colocated with wind, as a matter of fact.

Fort Bliss was among one of the first locations to build micro grid with mission insurance as its—as its objective. So we are here for everybody. We are kind of like the bacon of the grid. We make everything better.

[Laughter.]

Mr. OLSON. You know what Texans like to hear? The bacon of the grid. Mr. Moore?

Ms. SPEAKES-BACKMAN. I grew up in Ohio. I love bacon.

Mr. OLSON. Your comments, Mr. Moore.

Mr. MOORE. Sure. Just that people come from all over the world to see how Texas integrates large amounts of renewable energy onto the system.

ERCOT has done a terrific job with it and I think a key reason for the success, to echo another speaker, is the incredible amount of new transmission to pull the grid together.

So given that most outages are caused to the distribution transmission system with the, you know, wires and poles, let's focus on smart design for the system.

Mr. OLSON. All those praises for Texas. So join me: [singing] "The stars at night ..."

[Laughter.]

And seeing no further Members wish to ask questions, I would like to thank all of our witnesses for being here today.

And there is one document for the record. I ask unanimous consent that written testimony of Dr. Susan Tierney in a summary—she was supposed to be here, but she could not be here—be entered into the record.

Without objection.

[The information appears at the conclusion of the hearing.]

Mr. OLSON. And pursuant to committee rules, I remind Members that they have 10 business days to submit additional questions for the record and ask the witnesses to submit their response within 10 business days upon receipt of the questions.

And without objection, this committee is adjourned.

[Whereupon, at 4:23 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

Testimony of Susan F. Tierney, Ph.D.

Before the U.S. House of Representatives
Committee on Energy and Commerce
Subcommittee on Energy

Hearing on
"Powering America: Defining Reliability in a Transforming Electricity Industry"

September 12, 2017

Summary of Testimony

Good morning, Chairman Upton, Ranking Member Rush, and Members of the Subcommittee. My name is Susan Tierney, and I am a Senior Advisor at Analysis Group. Thank you for inviting me to testify on this important topic. I am testifying on my own behalf at today's hearing.

As you have heard from other witnesses today, the U.S. electric power system is undergoing a major transition. The changes have been driven predominantly by low natural gas prices, which have led to competition with output at coal plants. Flat electricity demand and declining costs of wind and solar power have played a much smaller role in the changing electricity mix. There is little doubt that the transition will lead to a power system with a resource mix and consumption patterns quite different from what the industry has experienced in recent decades. Contrary to what many public officials say, today's electric system is more diverse that in the past, and has contributed positively to declines in the overall cost of living.

These changes are taking place in the context of some important continuities, however, perhaps most notably the electric industry's successful maintenance of power-system reliability. Even so, a common occurrence in the industry is for observers to raise reliability concerns whenever technology, market or policy trends are affecting the balance of resources in the system and when some parties feel their particular interests will be adversely affected. The recent Grid Study by the Department of Energy itself sprang from Secretary Perry's stated concerns about whether certain policies were adversely affecting electric reliability. Raising the reliability red flag is a powerful tool in public discussions because reliability simply cannot be jeopardized.

But policy and/or market changes rarely if ever actually end up in reliability problems. Nevertheless, these discussions play an important role in focusing the attention of the industry on taking the steps necessary to continue to ensure reliable electric service to Americans.

The Federal Power Act, with the changes introduced with the Energy Policy Act of 2005, has contributed substantially to supporting the tools needed to assure a reliable power supply. The electric industry's many players are keenly organized and strongly oriented toward safe and reliable operations. There are well-established laws, rules, practices, procedures, agreements, investments, regulations, and enforceable standards that ensure reliable operations of the system, day in and day out. Even as low gas prices put financial pressure on all generating technologies, the system remains reliable.

Although Secretary Perry raised questions about whether "baseload power is necessary to a well-functioning grid," the DOE Staff Report appropriately identifies 'baseload' as an economic, rather than technology-specific concept, and recognizes that many of the coal plants that retired since 2002 were not operating as 'baseload' at the time of their retirement.

Indeed, reliability itself is a technology-neutral concept. As noted in NERC reviews of reliability, what is required to maintain a reliable system is a portfolio of resources in sufficient quantity that together can meet the system's operational needs for voltage support, frequency control, reactive and real power, ramping and load following capability, and the other essential reliability services needed to maintain operational reliability. Various simplifying terms used historically to describe the way power plants were operating – e.g., "baseload," "intermediate," and "peaking" – were for convenience, not to describe essential reliability services, or what technologies or fuels were required to maintain reliability. And despite how many observers have characterized the content of the study, the Grid Study itself does not support a finding that "baseload" resources are essential to the reliability of the power grid. The Report appropriately describes the many reliability services provided capably by various types of generating technologies.

There are, however, some interesting strains in the evolving power system. I discuss them in my full testimony, but I want to highlight four of them in particular: the growing interdependencies of the gas and electric industries; the increasing tensions arising from states' adoption of policies that affect prices in competitive wholesale markets; the need for better attention to electric-system resiliency and for R&D on modernizing the grid; and the implications of market conditions for existing nuclear plants that provide electricity without carbon emissions.

Improved coordination across the natural gas and electric industries is an issue of high and increasing importance, as noted in a number of recent reports (including the Grid Study and a July 2017 National Academy of Sciences committee report on electric-system resiliency, on which I participated). The latter stated that the "conventional wisdom is that the electric industry will become even more dependent upon natural gas than it has in recent years, and the natural gas industry looks to a future in which significant growth in demand depends upon developments in the power sector. For the electric system to become more reliable and resilient, attention must be paid to assure robust systems and practices across the two industries." FERC has authority to address electric system reliability issues, but not on the natural gas side. I encourage Congress to consider whether legislative modifications are needed to the Federal Power Act and/or the Natural Gas Act in light of the growing interdependencies of the two industries.

Regarding state policies and wholesale power markets: Few if any of the people who currently sit in state decision-making positions with responsibility for electric-industry matters were in those positions at the time their states decided to restructure their electric industries and to join a wholesale market regulated by FERC. It is not reasonable to expect that states will honor allegiance to the design of FERC-regulated markets more than their local objectives for economic development, clean energy, affordable power, distributed energy systems, mitigating climate change, and so forth. States will likely continue to adopt laws promoting one type of resource over another, and this will likely continue to raise tensions with FERC's responsibilities under the Federal Power Act. This deserves more congressional attention.

Given the essential role of electricity in modern society, the grid needs not only to be reliable but also more resilient. At a time when so many people are suffering from the impacts of flooding, wild fires, hurricanes and other severe weather events, I don't need to spend time explaining why improved grid resiliency is important. The range of potential disruptive events is broad, and the system needs to be designed to handle high-impact events ranging from severe weather to cyber attacks. This is the point of the recent National Academy Committee's grid report, and was an important finding and recommendation in the DOE Grid Study. Given that grid reliability and resiliency are so important, Congress and the Administration should be supporting more, rather than less, funding for R&D on modernizing the grid. The DOE's Electricity Advisory Committee (which I chaired until last month) recently endorsed such R&D as an essential federal function that is in the national interest.

Finally, in spite of what had been anticipated at the time Secretary Perry called for a new analysis, DOE's new Grid Study concluded that retirements of the least-efficient coal-fired power plants have resulted largely from fundamental market forces. This situation differs from that of existing nuclear units that are currently under financial pressure in wholesale markets where prices (and revenues) are tied to low gas prices: In contrast to coal plants, nuclear plants produce power without carbon emissions, and yet wholesale markets provide little if any compensation for this attribute. This market failure works to the detriment of nuclear plants and other non-carbon emitting generating technologies, like hydropower, wind, solar, and energy efficiency as well. Premature retirements of safely operating nuclear plants is of concern for this reason. Several states have been stepping up to address this issue in the absence of federal action.

Full Testimony

My name is Susan Tierney, and I am a Senior Advisor at Analysis Group, Inc., a 700-person economic consulting firm headquartered in Boston, Massachusetts, with other U.S. offices in California, Colorado, Illinois, New York, Texas, and Washington, D.C.

I appreciate the opportunity to testify today on the critically important topic of electric-system reliability.[1] I am testifying on my own behalf at today's hearing.[2]

[1] As indicated in my attached CV, I have been involved in issues related to public utilities, ratemaking and electric industry regulation, and energy and environmental economics and policy for over 25 years. During this period, I have worked on electric and gas industry issues as a utility regulator and energy/environmental policy maker, consultant, academic, and expert witness. I have been a consultant and advisor to private energy companies, grid operators, government agencies, large and small energy consumers, environmental organizations, foundations, Indian tribes, and other organizations on a variety of economic and policy issues in the energy sector. Before becoming a consultant, I held several senior governmental policy positions in state and federal government, having been appointed by elected executives from both political parties. I served as the Assistant Secretary for Policy at the U.S. Department of Energy from early 1993 through summer 1995. I held senior positions in the Massachusetts state government as Secretary of Environmental Affairs; Commissioner of the Department of Public Utilities; and Executive Director of the Energy Facilities Siting Council. My Ph.D. in regional planning is from Cornell University. I previously taught at the University of California at Irvine, and recently at the MIT. I am a Visiting Fellow in Policy Practice at the University of Chicago's Energy Policy Institute; and a member of the advisory councils at New York University's Policy Integrity Institute, Duke University's Nicholas School for the Environment, and Columbia University's Center for Global Energy Policy. I currently sit on several non-profit boards and commissions, including as chair of the Advisory Council of the National Renewable Energy Laboratory; chair of ClimateWorks Foundation; a director of World Resources Institute, the Energy Foundation, Resources for the Future, the Keystone Center, and the Alliance to Save Energy. I am a member of the NYISO's Environmental Advisory Council; and just completed service as the chair of the Department of Energy's Electricity Advisory Council and a member of the National Academy of Sciences committee on resiliency of the U.S. electric system. I was co-lead convening author of the Energy Supply and Use chapter of the National Climate Assessment, served on the Secretary of Energy's Advisory Board, and chaired the Policy Subgroup of the National Petroleum Council's study of the North American natural gas and oil resource base. Previously, I served as co-chair of the National Commission on Energy Policy, as a representative to

Although the nation's mix of electric generating resources has always changed over time, it is increasingly evident that the U.S. electric power system is now going through a major transition. The current changes have been driven by several things: fundamental shifts in the prices of fuels for power generation (in particular, natural gas); improvements in cost and performance of traditional and renewable generating technologies; the rapid emergence of many types of distributed energy resources including energy efficiency; preferences of customers, large and small; and state and federal policies promoting the development and commercialization of advanced energy technologies. There is little doubt that the transition in the industry will lead to a power system with a resource mix and consumption patterns quite different from the ones to which the industry has grown accustomed in recent decades. The increasing diversity of generation supply has lowered wholesale electricity costs in most parts of the U.S. and has contributed to recent declines in consumers' overall cost of living.[3]

These changes are taking place in the context of some important continuities – perhaps most notably the electric industry's successful maintenance of power-system reliability. Even so, a common occurrence in the industry is for observers to raise reliability concerns whenever technology, market or policy trends or events are affecting or may affect the balance of resources in the system. Such reliability concerns have been raised regularly over decades in the face of industry changes. It is a particularly powerful tool in public discussions, because reliability simply

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committees of the North American Electric Reliability Council; and a member of the National Academy of Sciences' Committee on Enhancing the Robustness and Resilience of Electrical Transmission and Distribution in the United States to Terrorist Attack.

[2] As indicated on my "Truth in Testimony" form, I am testifying on my own behalf, and neither on behalf of a governmental entity nor a non-governmental entity (other than myself). I have not received a federal grant (or subgrant) or contract (or subcontract) during the current fiscal year or either of the two preceding fiscal years.

[3] This paragraph is excerpted from a report I recently co-authored and which I have included as Attachment 1 to my statement: Paul Hibbard, Susan Tierney and Katherine Franklin, "Electricity Markets, Reliability and the Evolving U.S. Power System," June 2017. http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/ag_markets_reliability_final_june_2017.pdf.

cannot be jeopardized. Sometimes the warnings spring from genuine concerns, such as the need to address localized reliability impacts of potential plant closures; other times they reflect a first line of defense by opponents of the changes underway in the industry, or those potentially adversely affected. The recent Grid Study by the U.S. Department of Energy itself sprang from Secretary Perry's stated concerns about whether certain policies were adversely affecting electric security and reliability. So, there's a discernible pattern: the prospect of change riles people up in various ways, leading to new reliability assessments, careful evaluations of new and upcoming challenges, and concrete steps to lower the chances of reliability problems occurring.

In fact, policy and/or market changes rarely if ever actually end up adversely affecting electric system reliability. A vast network of entities and organizations, combined with a complex set of reliability laws, rules, practices, systems, and procedures, ensures this outcome. Nevertheless, these discussions play an important role in focusing the attention of the industry on taking the steps necessary to continue to ensure reliable electric service to Americans.

The Federal Power Act, including the changes that were introduced by the Energy Policy Act of 2005, has contributed substantially to supporting the tools needed by the industry to assure a reliable supply of power for Americans on a 24/7 basis. EPACT gave the Federal Energy Regulatory Commission increased authority to assure reliability through an industry standard-setting board (the North American Electric Reliability Corporation, or NERC) establishing mandatory standards to be implemented in the bulk power system, backed up by FERC's new enforcement capability.

The electric industry's many players are keenly organized and strongly oriented toward safe and reliable operations. There are well-established procedures, regulations, and enforceable standards in place to ensure reliable operations of the system, day in and day out.[4] Among other things, these "business-as-usual" procedures include:

- Assigning specific roles and responsibilities to different organizations, including regional reliability organizations, grid operators, power plant and transmission owners, regulators, and many others;
- Planning processes to look ahead at what actions and assets are needed to make sure that the overall system has the capabilities to run smoothly;
- Maintaining secure communication systems, operating protocols, and real-time monitoring processes to alert participants to any problems as they arise, and initiating corrective actions when needed; and
- Relying upon systems of reserves, asset redundancies, back-up action plans, and mutual-assistance plans that kick in automatically when some part of the system has a problem.

There are some interesting strains in the system, however. In particular, I want to call attention to the following four imperatives: the need to address issues relating to growing interdependencies of the gas and electric industries; the increasing tensions among state policies affecting prices in wholesale markets; the need for better attention to electric-system resiliency and for R&D related

[4] This paragraph and the bullets below it are an excerpt from a 2015 report I co-authored and which I have included as Attachment 2 to my statement: Susan Tierney, Paul Hibbard and Craig Aubuchon, "Electric System Reliability and EPA's Clean Power Plan: Tools and Practices," February 2015, http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/electric_system_reliability_and_epas_clean_power_plan_tools_and_practices.pdf.

to grid modernization; and the implications of market conditions for existing nuclear plants that provide electricity without carbon emissions.

The August 2017 Staff Report to the Secretary on Electricity Markets and Reliability (the "DOE Grid Study" or the "Staff Report") included a number of findings on these issues, and I agree with many of them, as I explain further below. But before I do, however, I need to distance myself from the Grid Study's original premise, grounded in the Secretary's April 14th letter directing the staff to prepare the report, is that "baseload power is necessary to a well-functioning grid." The Staff Report appropriately identifies that 'baseload' is an economic, rather than technology-specific concept, and recognizes that many of the coal plants that retired since 2002 were not operating as 'baseload' at the time of their retirement.[5] Historically, this phrase has applied to plants (such as nuclear and coal plants) that were expensive to build but cheap to operate, such that they ran around the clock. However, they are not the only types of technologies capable of providing around-the-clock power supply and other functions necessary for reliable electric system operations, as noted in the DOE Staff Report.

Reliability is a technology-neutral concept. As noted in NERC reviews of reliability, what is required to maintain a reliable system is a set of resources in sufficient quantity that together can meet the system's operational needs for voltage support, frequency control, reactive and real

[5] "Many of the power plants that retired between 2002 and 2016 were used for baseload generation in the past, but were no longer operating in that role at the time of retirement due to changes in electricity market dynamics. With the sustained drop in natural gas prices, for example, natural gas-fired combined-cycle (NGCC) plants are currently a less costly source of baseload generation than coal or nuclear power in many regions of the country." Grid Study, page 6 and also on page 39 " Low-cost, abundant natural gas and the development of highly-efficient NGCC plants resulted in a new baseload competitor to the existing coal, nuclear, and hydroelectric plants." Grid Study, page 13. "To date, however, the data do not show a widespread relationship between VRE penetration and baseload retirements." Grid Study, page 50.

power, ramping and load following capability, and so forth. While not all of a system's resources are equal when it comes to the attributes they provide to system operators to manage operational reliability, what is important is that the mix of resources available to system operators can in aggregate, and in combination with system operator actions, provide the essential reliability services needed to maintain operational reliability. In other words, various simplifications used historically to describe the way resources were being used – e.g., "baseload," "intermediate," and "peaking" – were used for convenience and simplicity, not to describe essential reliability services, or what was required to maintain reliability. The power system needs the combination of energy, capacity, and flexibility to maintain reliability.

Despite how many observers have characterized the content of the study, the Staff Report does not support a finding that "baseload" resources are essential to the reliability of the power grid. The Report appropriately describes the many reliability services provide in the past and today by various types of generating technologies.

There are some findings of the Grid Study with which I agree. (The quoted text in the bulleted paragraphs below is from the Grid Study.)

- The nation's "centrally-organized markets have achieved reliable wholesale electricity delivery with economic efficiencies in their short-term operations....[and] are currently functioning as designed—to ensure reliability and minimize the short-term costs of wholesale electricity—despite pressures from flat demand growth, Federal and state policy interventions, and the massive economic shift in the relative economics of natural gas compared to other fuels." This is the same conclusion my co-authors and I reached in a study we produced in June 2017. (See Attachment 1 to my testimony today.)

- "Market designs may be inadequate given potential future challenges. VRE [variable renewable energy]—with near-zero marginal costs and if at high penetrations—will lower wholesale energy prices independent of effects of the current low natural gas prices...requiring careful consideration of continued market evolutions." This is a point I made in a statement before the Federal Energy Regulatory Commission at its May 2017 Technical Conference[6] and in a prior statement at FERC's 2013 Technical Conference on Capacity Markets.[7] (Attachments 3 and 4 to my statement here today.)

- "While power plants retire for a variety of reasons, several factors have contributed to recent retirements and continuing pressure for additional retirements. The biggest contributor to coal and nuclear plant retirements has been the advantaged economics of natural gas-fired generation." Also, these "trends have placed a premium on flexible output rather than the steady output of traditional baseload power plants. This flexibility is generally provided by generation resources. However, nongeneration sources of flexibility—such as flexible demand, increased transmission, and energy storage technologies—are being explored as ways to enhance system flexibility." These are points I have made in two reports: one, on the implications of current wholesale power markets for existing coal plants;[8] the other on the

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[6] Comments of Susan F. Tierney before the Federal Energy Regulatory Commission, Docket No. AD17-11-000, State Policies and Wholesale Markets Operated by ISO New England Inc., New York Independent System Operator, Inc., and PJM Interconnection, L.L.C., May 2 2017. https://www.ferc.gov/CalendarFiles/20170426151811-Tierney,%20Analysis%20Group.pdf.

[7] Comments of Susan F. Tierney before the Federal Energy Regulatory Commission, Docket No. AD13-7-000, September 9, 2013. https://www.ferc.gov/CalendarFiles/20130911145004-Tierney%20Comments.pdf.

[8] Susan Tierney, "Why Coal Plants Retire: Market Fundamentals as of 2012," February 16, 2012, http://www.analysisgroup.com/uploadedfiles/content/news_and_events/news/2012_tierney_whycoalplantsretire.pdf. Susan Tierney,

implications for existing nuclear plants of current market conditions *and* the absence of policies to compensate suppliers of electricity from technologies with no carbon emissions).[9]

- "Markets need further study and reform to address future services essential to grid reliability and resilience. System operators are working toward recognizing, defining, and compensating for resource attributes that enhance reliability and resilience (on both the supply and demand side). However, further efforts should reflect the urgent need for clear definitions of reliability and resilience-enhancing attributes and should quickly establish the market means to value or the regulatory means to provide them." This is a point I made in the reports and comments I noted previously, as well as in a recent report of the National Academy of Sciences ("NAS") Committee on Enhancing the Resilience of the Nation's Electric Power Transmission and Distribution System (on which I served as a committee member).[10] Note that the NAS report found that "a resilient system is one that acknowledges that outages can occur, prepares to deal with them, minimizes their impact when they occur, is able to restore service quickly, and draws lessons from the experience to improve performance in the future."[11]

- "Society places value on attributes of electricity provision beyond those compensated by the current design of the wholesale market. Americans and their elected representatives value the various benefits specific power plants offer, such as jobs, community economic

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"The U.S. Coal Industry: Challenging Transitions in the 21st Century," September 2016, http://www.analysisgroup.com/insights/publishing/the-u-s--coal-industry--challenging-transitions-in-the-21st-century/

[9] Susan Tierney, "Don't let nuke plants go too fast," The Hill, July 15, 2015. http://thehill.com/opinion/op-ed/247858-dont-let-nuke-plants-go-too-fast.

[10] National Academies of Sciences, Engineering, and Medicine. 2017. Enhancing the Resilience of the Nation's Electricity System. Washington, D.C.: The National Academies Press: https://doi.org/10.17226/24836. (hereafter referred to as the "NAS Report") https://www.nap.edu/catalog/24836/enhancing-the-resilience-of-the-nations-electricity-system.

[11] NAS Report, page 1-6.

development, low emissions, local tax payments, resilience, energy security, or the national security benefits associated with a nuclear industrial base. Most of these benefits are not recognized or compensated by wholesale electricity markets, and this has given rise to a variety of state and private efforts that include keeping open or shutting down established baseload generators and incentivizing VRE generation." This is a point I made in my comments at FERC's Technical Conferences, noted above.

- "Fuel assurance is a growing consideration for the electricity system. Maintaining onsite fuel resources is one way to improve fuel assurance, but most generation technologies have experienced fuel deliverability challenges in the past." I have made this point in many of the studies noted above.

- "Recent severe weather events have demonstrated the need to improve system resilience. The range of potential disruptive events is broad, and the system needs to be designed to handle high-impact, low probability events. This makes it very challenging to develop cost-effective programs to improve resilience at the regional, state, or utility levels. Planning, practice, and coordination on an all-hazards basis and having a mix of resources and fuels available when a major disturbance occurs are both essential to fast response. Work still remains to identify facilities that merit hardening; stage periodic exercises and drills so that governmental agencies and utilities are prepared for emergencies; and ensure that wholesale electricity markets are designed to recognize and incentivize investments that would achieve or enhance resilience-related objectives." This is consistent with our Committee's findings in the recent National Academy of Science report on grid resiliency.

I agree with some -- but not all -- of the recommendations made by the DOE staff in their report to Secretary Perry. For example, I agree with the following recommendations -- and have previously stated similar positions in various public settings.

- "FERC should expedite its efforts with states, RTO/ISOs, and other stakeholders to improve energy price formation in centrally-organized wholesale electricity markets." This is a worthwhile focus on FERC's attention, as I have previously conveyed to the FERC itself.
- "Where feasible and within its statutory authority, FERC should study and make recommendations regarding efforts to require valuation of new and existing ESS [Essential Reliability Services] by creating fuel-neutral markets and/or regulatory mechanisms that compensate grid participants for services that are necessary to support reliable grid operations,,,. [This could include more study of] mechanisms for enabling equitable, value-based remuneration for desired grid attributes—such as ERS, fuel availability, high resilience, low emissions, flexibility, etc.—with alternative market and non-market structures." As my co-authors and I describe in detail in our June 2017 study (Attachment 1 to this testimony), different generating technologies -- both conventional and advanced energy technologies -- provide different reliability services, and no technology provides all of the services required to keep the system operating reliably. Wholesale markets should include compensation for these differentiated services.
- FERC should continue to "evaluate ongoing capacity market reforms." And, "with significant amounts of near-zero marginal cost generation available, security-constrained economic dispatch of BPS based on marginal costs may not sufficiently compensate resources

for all fixed and variable costs. Academic and other research should be expanded in this area, to include capacity market reforms and the role of capacity markets in a higher VRE/low marginal cost system." I have stated my view in my comments at the 2013 and 2017 FERC Technical Conferences that capacity markets as currently structured may not be sustainable, especially in light of current energy-market conditions based on low natural-gas costs and with increasing shares of resources having high fixed costs and no-to-low operating costs. This, too, is one of the reasons why many states are now taking action (e.g., encouraging long-term bilateral contracts with certain generators; establishing policies like zero-emission credits), and, in the process, creating the kinds of tensions with the Federal Power Act that have led to major court cases and opinions in recent years.

- "DOE should support utility, grid operator, and consumer efforts to enhance system resilience. Transmission planning entities should conduct periodic disaster preparedness exercises involving electric utilities, regional offices of Federal agencies, and state agencies...DOE should focus R&D efforts to enhance utility, grid operator, and consumer efforts to enhance system reliability and resilience....Focus R&D on improving VRE integration through grid modernization technologies that can increase grid operational flexibility and reliability through a variety of innovations in sensors and controls, storage technology, grid integration, and advanced power electronics. The Grid Modernization Initiative should also consider additional applications of high-performance computing for grid modeling to advance grid resilience." The Staff Report's recommendations point to the significance of a robust portfolio of grid-modernization research, something that the DOE's

Electricity Advisory Council (which I chaired until last month) endorsed as an essential federal function in the national interest.[12]

- "Utilities, states, FERC, and DOE should support increased coordination between the electric and natural gas industries to address potential reliability and resilience concerns associated with organizational and infrastructure differences." I agree strongly with this point, as I explain further below.

- "EIA [the Energy Information Administration] and NERC should examine ways to improve power generator fuel delivery data collection; additional data on fuel deliveries and potential disruptions would further improve forecasting necessary for electric reliability planning." This would be helpful in enhancing visibility about fuel supplies to power plants.

- "Develop policy metrics and tools for evaluating BPS [bulk power system]-wide provision of resilience and considering all aspects of the electricity system that contribute to resilience, including regional generation characteristics, imports and exports, fuel supply and storage, transmission capability, DR [demand response], electricity storage, inertia, and other factors that determine the ability of grid operators to provide reliable electricity supplies.... Each RTO/ISO should strive to explicitly define resilience on its system and conduct resource diversity assessments to more fully understand the resilience of different resource portfolios. Federal, state, and local work to define and support system-wide resilience is also needed."

[12] Susan Tierney, Chair, Electricity Advisory Committee, to Patricia Hoffman, Acting Assistant Secretary for Electricity Delivery and Energy Reliability, "New Technologies Require A Modern Grid: Report on the Department of Energy Grid Modernization Initiative," June 2017, https://energy.gov/sites/prod/files/2017/06/f34/EAC%20-%20New%20Technologies%20Require%20a%20Modern%20Grid%2C%20Report%20on%20the%20US%20DOE%20GMI%20-... 0.pdf. (Included as Attachment 5 to this testimony.)

The recent NAS Report makes similar findings and recommendations on the need for resiliency metrics.

So, while I am in agreement with many of the Grid Study's recommendations, there are others with which I disagree. I do not agree with the Staff Report's recommendations relating to "energy dominance" and do not believe that those recommendations logically follow from the factual findings in the Grid Study itself. Furthermore, I disagree with the recommendations relating to modifications of the Environmental Protection Agency's New Source Review program for coal-fired power plants. Retirements of coal-fired power plants are largely the result of fundamental market forces, and not New Source Review. In fact, such retirements have rendered the system more diverse, not less: the retirements of many of the least-efficient coal-fired power plants, combined with the increase in gas-fired generation and output at central-station and distributed wind and solar facilities, and the availability of new systems to manage certain loads have supported a more diverse and reliable system.

Further, coal-fired power plants benefit from the absence of carbon-control policies in most parts of the nation – a benefit that, by the way, nuclear power does not get. This market failure works to the detriment of nuclear plants and other non-carbon emitting generating technologies, like hydropower, wind, solar, and energy efficiency as well). This is the attribute of nuclear technologies for which most wholesale power markets fundamentally fail to provide much (if any) compensation. Premature retirements of safely operating nuclear plants deserves differential attention from coal-fired power plants as a result. Unfortunately, the Staff Report did not draw this inherent distinction between the attributes of power supplied by nuclear plants relative to coal-fired power plants. Several states have been stepping up to address this issue in the absence of federal action.

Finally, with regard to the issue of improved coordination of the natural gas and electric industries, I want to make one additional comment: This is an issue of high and increasing importance, with attention called to this by the recent NAS Report, by the FERC, by parties associated with the North American Energy Standards Board ("NAESB"), and many others. As summarized in the NAS Report: "The conventional wisdom is that the electric industry will become even more dependent upon natural gas than it has in recent years, and the natural gas industry looks to a future in which significant growth in demand depends upon developments in the power sector. For the electric system to become more reliable and resilient, attention must be paid to assure robust systems and practices across the two industries." FERC enjoys authority to address electric system reliability issues, and has rate-making and other regulatory authority over segments of the natural-gas industry. But there are portions of the electricity and natural-gas supply chains (e.g., natural-gas production) that are not regulated by a reliability entity. Much of the discussion on the gas/electric system interdependency issues relates to deliveries of gas on a just-in-time basis to an electric system that increasingly requires dispatch of nimble and fast-ramping gas-fired power plants. But there are also other imperative concerns that also need to be addressed, notably the need for cyber security on the gas side to bring it in line with the electric side, which itself is in increasing its own cyber-control systems. For multiple important reasons, Congress needs to pay special attention to whether there are legislative modifications needed to the Federal Power Act and/or the Natural Gas Act.

Testimony of Susan F. Tierney, Ph.D.
Before the U.S. House of Representatives
Committee on Energy and Commerce, Subcommittee on Energy
Hearing on "Powering America: Defining Reliability in a Transforming Electricity Industry"
September 12, 2017

Summary of Testimony

Good morning, Chairman Upton, Ranking Member Rush, and Members of the Subcommittee. My name is Susan Tierney, and I am a Senior Advisor at Analysis Group. Thank you for inviting me to testify on this important topic. I am testifying on my own behalf at today's hearing.

As you have heard from other witnesses today, the U.S. electric power system is undergoing a major transition. The changes have been driven predominantly by low natural gas prices, which have led to competition with output at coal plants. Flat electricity demand and declining costs of wind and solar power have played a much smaller role in the changing electricity mix. There is little doubt that the transition will lead to a power system with a resource mix and consumption patterns quite different from what the industry has experienced in recent decades. Contrary to what many public officials say, today's electric system is more diverse that in the past, and has contributed positively to declines in the overall cost of living.

These changes are taking place in the context of some important continuities, however, perhaps most notably the electric industry's successful maintenance of power-system reliability. Even so, a common occurrence in the industry is for observers to raise reliability concerns whenever technology, market or policy trends are affecting the balance of resources in the system and when some parties feel their particular interests will be adversely affected. The recent Grid Study by the Department of Energy itself sprang from Secretary Perry's stated concerns about whether certain policies were adversely affecting electric reliability. Raising the reliability red flag is a powerful tool in public discussions because reliability simply cannot be jeopardized.

But policy and/or market changes rarely if ever actually end up in reliability problems. Nevertheless, these discussions play an important role in focusing the attention of the industry on taking the steps necessary to continue to ensure reliable electric service to Americans.

The Federal Power Act, with the changes introduced with the Energy Policy Act of 2005, has contributed substantially to supporting the tools needed to assure a reliable power supply. The electric industry's many players are keenly organized and strongly oriented toward safe and reliable operations. There are well-established laws, rules, practices, procedures, agreements, investments, regulations, and enforceable standards that ensure reliable operations of the system, day in and day out. Even as low gas prices put financial pressure on all generating technologies, the system remains reliable.

Although Secretary Perry raised questions about whether "baseload power is necessary to a well-functioning grid," the DOE Staff Report appropriately identifies 'baseload' as an economic, rather than technology-specific concept, and recognizes that many of the coal plants that retired since 2002 were not operating as 'baseload' at the time of their retirement.

Indeed, reliability itself is a technology-neutral concept. As noted in NERC reviews of reliability, what is required to maintain a reliable system is a portfolio of resources in sufficient quantity that together can meet the system's operational needs for voltage support, frequency control, reactive and real power, ramping and load following capability, and the other essential reliability services needed to maintain operational reliability. Various simplifying terms used historically to describe the way power plants were operating – e.g., "baseload," "intermediate," and "peaking" – were for convenience, not to describe essential reliability services, or what technologies or fuels were required to maintain reliability. And despite how many observers have characterized the content of the study, the Grid Study itself does not support a finding that "baseload" resources are essential to the reliability of the power grid. The Report appropriately describes the many reliability services provided capably by various types of generating technologies.

There are, however, some interesting strains in the evolving power system. I discuss them in my full testimony, but I want to highlight four of them in particular: the growing interdependencies of the gas and electric industries; the increasing tensions arising from states' adoption of policies that affect prices in competitive wholesale markets; the need for better attention to electric-system resiliency and for R&D on modernizing the grid; and the implications of market conditions for existing nuclear plants that provide electricity without carbon emissions.

Improved coordination across the natural gas and electric industries is an issue of high and increasing importance, as noted in a number of recent reports (including the Grid Study and a July 2017 National Academy of Sciences committee report on electric-system resiliency, on which I participated). The latter stated that the "conventional wisdom is that the electric industry will become even more dependent upon natural gas than it has in recent years, and the natural gas industry looks to a future in which significant growth in demand depends upon developments in the power sector. For the electric system to become more reliable and resilient, attention must be paid to assure robust systems and practices across the two industries." FERC has authority to address electric system reliability issues, but not on the natural gas side. I encourage Congress to consider whether legislative modifications are needed to the Federal Power Act and/or the Natural Gas Act in light of the growing interdependencies of the two industries.

Regarding state policies and wholesale power markets: Few if any of the people who currently sit in state decision-making positions with responsibility for electric-industry matters were in those positions at the time their states decided to restructure their electric industries and to join a wholesale market regulated by FERC. It is not reasonable to expect that states will honor allegiance to the design of FERC-regulated markets more than their local objectives for economic development, clean energy, affordable power, distributed energy systems, mitigating climate change, and so forth. States will likely continue to adopt laws promoting one type of resource over another, and this will likely continue to raise tensions with FERC's responsibilities under the Federal Power Act. This deserves more congressional attention.

Given the essential role of electricity in modern society, the grid needs not only to be reliable but also more resilient. At a time when so many people are suffering from the impacts of flooding, wild fires, hurricanes and other severe weather events, I don't need to spend time explaining why improved grid resiliency is important. The range of potential disruptive events is broad, and the system needs to be designed to handle high-impact events ranging from severe weather to cyber attacks. This is the point of the recent National Academy Committee's grid report, and was an important finding and recommendation in the DOE Grid Study. Given that grid reliability and resiliency are so important, Congress and the Administration should be supporting more, rather than less, funding for R&D on modernizing the grid. The DOE's Electricity Advisory Committee (which I chaired until last month) recently endorsed such R&D as an essential federal function that is in the national interest.

Finally, in spite of what had been anticipated at the time Secretary Perry called for a new analysis, DOE's new Grid Study concluded that retirements of the least-efficient coal-fired power plants have resulted largely from fundamental market forces. This situation differs from that of existing nuclear units that are currently under financial pressure in wholesale markets where prices (and revenues) are tied to low gas prices: In contrast to coal plants, nuclear plants produce power without carbon emissions, and yet wholesale markets provide little if any compensation for this attribute. This market failure works to the detriment of nuclear plants and other non-carbon emitting generating technologies, like hydropower, wind, solar, and energy efficiency as well. Premature retirements of safely operating nuclear plants is of concern for this reason. Several states have been stepping up to address this issue in the absence of federal action.

My full testimony provides support for these and other comments, and I appreciate this opportunity to share it with you.

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE

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October 30, 2017

Mr. Steve Wright
General Manager
Chelan Public Utility District
P.O. Box 1231
Wenatchee, WA 98807

Dear Mr. Wright:

Thank you for appearing before the Subcommittee on Energy on Tuesday, October 3, 2017, to testify at the hearing entitled "Part II: Powering America: Defining Reliability in a Transforming Electricity Industry."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Monday, November 13, 2017. Your responses should be mailed to Allie Bury, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Allie.Bury@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

U.S. House of Representatives Committee on Energy and Commerce
Subcommittee on Energy
October 3, 2017 Hearing: "Part II: Powering American: Defining Reliability in a Transforming Electric Industry"

The Honorable Richard Hudson

1. Mr. Wright, hydropower has been a significant contributor of baseload electricity for a very long time. As you know, it consistently ranks as one of the cheapest and cleanest forms of energy.

a. Do you think there are opportunities to increase the nation's hydropower capacity.

A: Yes, the National Hydropower Association believes there are tremendous opportunities to increase hydropower capacity. In fact, the U.S. Department of Energy believes the same as highlighted in their 2016 Hydropower Vision Report. In the Report, DOE estimates that that close to 50 GW of new capacity is available by 2050, with the right conditions and policy support in place.

Potential growth in the hydropower industry comes from a variety of sources. They include: efficiency improvements and capacity additions at existing hydropower facilities; adding generation to non-powered dams (only 3 percent of U.S. dams generate power); pumped storage; conduit/irrigation power projects; as well as some new greenfield hydropower development.

NHA notes that additional capacity not captured in the DOE Hydropower Vision report is available in the marine energy and hydrokinetic sector, with projects that utilize ocean waves, ocean currents, tides and instream technologies.

Chelan PUD has front-line experience in expanding our existing hydropower resources. Between 1996 and 2006, Chelan PUD modernized the 1300 MW Rocky Reach Hydroelectric Project, replacing and upgrading turbines and generating equipment for a 4 percent peak efficiency gain. Between 2010 and 2011, we carried out an upgrade at the Lake Chelan Hydroelectric Project, increasing installed capacity from 48 MW to 59.2 MW by replacing existing turbines and generators with new units. We are currently modernizing the 624 MW Rock Island Hydroelectric Project. Through 2022 we will be modernizing Rock Island Powerhouse 1, with an expected peak efficiency gain of 12%. From 2021 to 2029, we will be modernizing Rock Island Powerhouse 2. At Powerhouse 2, we anticipate minimal generation gains, but the significant modernization effort is necessary to support ongoing operation of the project for the subsequent 40 years.

<u>The Honorable Peter Welch</u>

1. In DOE's recent request that FERC raise the prices of so called "baseload power" to keep coal and nuclear plants online, the agency says it is necessary because of "energy outages expected to result from the loss of this fuel-secure generation" and because of "recognition that organized markets do not pay generators for all the attributes they provide."

a. Whether or not that is true, do you believe generators of solar, wind, and energy storage are compensated fully for their attributes in wholesale markets.

A: Focusing on hydropower and pumped storage project owners, on behalf of whom I testified as the NHA witness, the Association does not believe that our sector is fully compensated for the grid reliability benefits that it provides. NHA stated so in its response to the Federal Energy Regulatory Commission's request for comments on the DOE proposal, reiterating the position it has made in many comments to FERC and other agencies that have investigated this issue over the years.

The U.S. Department of Energy in its 2016 Hydropower Vision Report agreed with this assessment, writing:

> "Hydropower plays a vital role in grid operation through its unique performance attributes and long-lasting facilities. In addition to providing energy production, capacity, and ancillary grid support services (as designated by the Federal Energy Regulatory Commission [FERC]), hydropower offers operational flexibility, energy storage, and other services essential to the continued reliability of the entire power system. **Improved market structures and compensation mechanisms could more appropriately reward new and existing hydropower for the numerous services and benefits it provides.** Important actions in this area include determining how much flexibility is provided by hydropower in existing grid operations, exploring opportunities to enhance market valuation of that flexibility, and examining how and at what time scale settlement of prices in energy markets could facilitate better use of hydropower flexibility to support integration of variable renewable generation resources. Additionally, improving the valuation and revenue of PSH services would help optimize PSH facility operation to benefit the entire electric system and stimulate new projects through improved economic performance." [emphasis added]

In its response to FERC, NHA also noted that capacity products tend to be undervalued when there is an energy surplus. The Association urged the Commission to recognize the changing generating resource mix and its impact on the availability of essential reliability services and examine remedies within a regional context. NHA suggested further work should be undertaken to study the value of rotating mass-based inertia, flexible capacity and resource sufficiency requirements.

b. Do wholesale markets price any electricity sources based on their attributes and how they benefit the public?

NHA agrees with the Department of Energy's notice of proposed rulemaking (82 FR 46940-46948) that current markets "do not necessarily pay generators for all the attributes they provide to the grid, including resiliency." In NHA's comments on the NOPR, the Association stated that this is particularly true for America's hydropower and pumped storage fleet, which is not adequately compensated for these essential services.

As I mentioned in my testimony, hydropower is the premiere electric generating resource. It is low cost, emission-free and, unlike any other generating resource, can provide *all* components of reliability, including: energy, peak capacity, voltage support, regulation, spinning and non-spinning reserves, storage, black start capability, and inertia. Hydro generators and pumped storage resources can normally be operational very quickly to support grid restoration. They typically have adequate fuel supply and (both in the reservoir and the rivers themselves, which are continuous source of fuel that is not dependent on man-made delivery systems) and can provide a sustained response. Yet market rules generally do not value, or undervalue, these characteristics, which significantly benefit the public.

As part of FERC's process in response to the NOPR, NHA recommends that the Federal Energy Regulatory Commission work with the ISOs and RTOs to define services and attributes that support reliable and resilient grid outcomes, rather than focusing too narrowly on a subset of eligible resources.

c. Do you think DOE is suggesting that FERC create a Value of Coal Tariff to price in non-monetizable attributes?

As NHA wrote to FERC in response to the notice of proposed rulemaking, compensation should be focused on the reliability and resiliency attributes or outcomes that warrant compensation themselves, without tying them to the specific fuel types that may provide them. If a final rule zeroes in on a narrow interpretation of the 90-day onsite fuel supply requirement, it appears it would largely benefit only coal and nuclear resources to the potential exclusion of hydropower or other resources that could also fulfill reliability and resilience needs.

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
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October 30, 2017

Mr. Christopher Mansour
Vice President of Federal Affairs
Solar Energy Industries Association
600 14th Street, N.W.; Suite 400
Washington, DC 20005

Dear Mr. Mansour:

Thank you for appearing before the Subcommittee on Energy on Tuesday, October 3, 2017, to testify at the hearing entitled "Part II: Powering America: Defining Reliability in a Transforming Electricity Industry."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

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Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

RESPONSE TO QUESTIONS FOR THE RECORD OF

CHRISTOPHER MANSOUR
VICE PRESIDENT, FEDERAL AFFAIRS
SOLAR ENERGY INDUSTRIES ASSOCIATION

BEFORE THE

HOUSE SUBCOMMITTEE ON ENERGY

HEARING ON

Powering America: Defining Reliability in a Transforming Electricity Industry

HELD ON OCTOBER 3, 2017

SEIA Solar Energy Industries Association®

Solar Energy Industries Association
600 14th Street NW, Suite 400
Washington, DC 20005
(202) 682-0556
www.seia.org

The Honorable Richard Hudson

1. **The solar industry has seen incredible growth in my home state of North Carolina over the past few years. In fact, we are currently ranked 2nd in the nation for solar energy capacity.**
    a. **Mr. Mansour, can you explain more about the role solar energy plays in maintaining a reliable and resilient electricity system?**

That's correct. North Carolina is one of the fastest-growing solar states in the country. There are more than 3,500 MW of solar installed to-date in North Carolina, enough to power 400,000 homes. Solar investment tops $5.5 billion and more than 250 solar companies call North Carolina home.

Solar energy is a key resource in ensuring a reliable and resilient electric system. Solar can be deployed in a variety of applications, providing electricity to homeowners, businesses, and the wholesale power grid. Distributed generation (DG) solar can help to reduce peak load on overtaxed feeders. When coupled with batteries or used in a microgrid configuration, DG solar can provide power during an outage to a hospital or community center. Connected to the wholesale grid, utility-scale solar increases generation fuel diversity and can be sited to relieve transmission constraints. On the whole, solar's varied applications allow it to increase the reliability and resilience of any electric system to which it connects.

The Honorable Peter Welch

1. **In DOE's recent request that FERC raise the price of so called "baseload power" to keep coal and nuclear plants online, the agency says it's necessary because of "energy outages expected to result from the loss of this fuel-secure generation" and because of "recognition that organized markets do not pay generators for all the attributes they provide."**
    a. **Whether or not that is true, do you believe generators of solar, wind, and energy storage are compensated fully for their attributes in wholesale markets?**

There are many attributes that are uncompensated in wholesale markets today. Currently, wholesale electricity markets do not place a value on zero-carbon resources. In addition, ancillary services are frequently provided as a bundled product, along with energy, from traditional generation sources, but they are not expected (nor compensated for) from renewable generators, and there are no wholesale markets that procure ancillary services on a competitive basis. As I stated in my written testimony, solar has proven that it is capable of providing essential reliability services to the grid.

b. **Do wholesale markets price any electricity source based on their attributes and how they benefit the public?**

No. Today's wholesale markets are designed to produce a "security-constrained economic dispatch." That is, the computer algorithms produce a result that dispatches generation with the lowest bid-in price, while simultaneously meeting all of the reliability requirements needed for that system operator. These day-ahead and hour-ahead markets value resources with the lowest marginal price, all other factors being equal. It is important to note that many factors are not included in a unit's marginal price, such as future waste disposal costs or the benefits derived from not polluting.

In these algorithms, reliability needs outweigh price. If a reliability need must be met in a certain geographic area, a higher-priced generation resource that can meet the reliability need will be selected over a lower-priced resource and paid its higher marginal cost.

c. Do you think DOE is suggesting that FERC create a Value of Coal Tariff to price in non-monetizable attributes?

I cannot speak to DOE's intention to create a "Value of Coal Tariff" with this proposal. However, there is clear evidence that energy outages are not expected, even if certain coal and nuclear generators retire. This is well-documented in a recent report by The Brattle Group[1]:

> The most recent surveys find that current and projected resource adequacy will remain within normal bounds and that sufficient generation resources will provide a high level of reliability against known and likely contingencies. FERC's recent *Energy Market Assessment for Winter 2017–2018* uses preliminary data from NERC's forthcoming 2017–2018 Winter Reliability Assessment to project healthy reserve margins for all assessment areas. In PJM, where the largest number of retirements has occurred (and where the vast majority of plants eligible under the proposed rule reside), the latest capacity auction indicates substantial surplus: a competitive market result procuring 6.7% more than the 16.6% target adequacy reserve margin for 2020/21. Over longer time scales (5 and 10 years), NERC projects that all U.S. regions will exceed target reserve margins in 2021, with only Midcontinent ISO ("MISO") falling short starting in 2022.

[1] The Brattle Group, Evaluation of the DOE's Proposed Grid Resiliency Pricing Rule, pp. 6-7, footnotes omitted. Available at
http://brattle.com/system/publications/pdfs/000/005/530/original/Evaluation_of_the_DOE's_Proposed_Grid_Resiliency_Pricing_Rule.pdf?1509064658.