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%20 President%20%26%20CEO%2C%20North%20American%20Electric%20Reliability%20Corp..pdf.