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

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

Office of Electricity Delivery and Energy Reliability Reorganization

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

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

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

Office of Electricity Priorities

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

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

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

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

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

Electricity Related Research & Development Efforts

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

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

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

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

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

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

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

Cybersecurity Research & Development Efforts

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

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

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

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

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

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

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

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

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

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

Conclusion

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

Thank you, and I look forward to your questions.