Department of Energy
Washington, DC 20585

February 14, 2017

MEMORANDUM TO THE DEPARTMENT OF ENERGY
ELECTRICITY ADVISORY COMMITTEE

From: **Patricia A. Hoffman**
Acting Assistant Secretary
Office of Electricity Delivery and Energy Reliability

Subject: **DOE Response to EAC Work Product**

I want to thank all members of the Department of Energy's (DOE) Electricity Advisory Committee (EAC) for your hard work during 2016.

The work product delivered by the Committee during this period is listed below. The purpose of this memo and its attachment is to provide you with the Department's response to your analyses and recommendations in a systematic and inclusive form.

EAC March 2016 Work Product:

National Distributed Energy Storage in the Electric Grid, March 2016

The attachment that follows summarize DOE's actions and response to this March 2016 work product.

I continue to look forward to the future efforts of the EAC and am committed to ensuring a strong and fruitful working relationship between the Committee and DOE.

Electricity Advisory Committee (EAC) Recommendations
National Distributed Energy Storage in the Electric Grid
March 2016

The Electricity Advisory Committee's (EAC) subcommittee on Distributed Energy Storage (DES) has completed a review of the DES market and offered several recommendations. OE-10 greatly appreciates the efforts of the EAC in reviewing the activities of the DOE related to grid energy storage, and values the insights offered by the EAC members. OE-10 has reviewed the recommendations of the EAC report and has organized responses on the eight recommendations made by the Subcommittee.

Recommendation 1: Access and track lessons learned from projects and market developments of DES

DOE has implemented a Global Energy Storage Database (GESDB) that is accessible at: http://www.energystorageexchange.org/ . This knowledge hub is a resource with a comprehensive database of Energy Storage projects nationally and internationally. In addition to providing a summary of energy storage deployments based on categories such as technology, location, and applications, the database has a number of visualization tools that are widely used by the industry. The database team routinely monitor the database to insure up-to-date and accurate information is provided on the projects. GESDB is a valuable industry resource by technology developers, utilities, project developers, and industry decision makers and had over 2.3M page views since inception in 2013 and 938k page-views in 2016 alone. While the information on the GESDB is mostly related utility class energy storage, it is rapidly developing data related to DER and behind the meter storage projects.

DOE, through Sandia National Laboratories, has developed Energy Storage Technology Advancement Program (ESTAP) as a platform to facilitate dissemination of lessons learned through a web-based information delivery platform (http://www.cesa.org/projects/energy-storage-technology-advancement-partnership/). This resource helps state energy offices develop a robust understanding of Energy Storage with the goal to help them in the development of Energy Storage (ES) policy and state supported projects. In addition to technical support to develop and implement of ES projects, the program continues to deliver informational webinars on energy storage technologies and disseminate learned from various DOE supported projects to state level energy offices, project planners and other relevant stakeholders.

Recommendation 2: Develop advanced market and cost-based market models for DES

With support from DOE, the National Laboratories have been active in advancing cost and valuation models for energy storage. Sandia National Laboratories has developed open-source Python based modeling tools for evaluating potential revenue streams from electrical energy storage in market areas. These tools can be used to model the potential revenue an aggregator can expect given historical market prices. These tools will be published on the DOE OE Energy Storage Systems program website in FY17. For vertically integrated utilities, estimating the potential savings from DES requires a production cost modelling analysis. Sandia has developed tools for stochastic unit commitment (open-source Python code) that will be updated to include distributed energy storage models in FY17. This tool will be crucial for performing the rigorous analysis required for rate-based considerations.

Pacific Northwest National Laboratory has developed two optimization tools that can identify the proper size and use of energy storage systems, easing the path to integration (http://availabletechnologies.pnnl.gov/technology.asp?id=413). These tools can be used by energy planners, public utilities, and businesses to determine the cost effectiveness of various energy storage approaches, before attempting to incorporate new technologies into their systems. The Battery Storage Evaluation Tool (BSET) is a computer model that simulates the use of an energy storage system in a local environment to meet multiple objectives and determine how to control the battery in an optimal manner such that total benefits are maximized. The tool is ideal for non-market areas in that it enables the user to monetize the annual value obtained for each service in a certain region allowing a comprehensive view of the best way to use an energy storage system. More specific to DES, the Optimal Sizing Tool for Battery Storage in Grid Applications looks at energy storage systems on the consumer side. The tool addresses the two most fundamental problems in behind-the-meter energy storage 1) what are the economic benefits of a storage system, and 2) what is the most economic energy and power size for the system. The tool analyzes trade-offs between benefits and costs so as to optimize battery size. The results can guide the purchase and use of behind-the-meter energy storage systems for businesses and determines the benefits of placing a battery storage system behind-the-meter rather than as part of the electric grid/utility.

Recommendation 3: Develop advanced modern grid physical models for DES

OE through funding at Sandia National Laboratories and Pacific Northwest National Laboratory has developed expertize modeling energy storage at the transmission level. OE agrees with the EAC recommendation that better models are required at the distribution level, as well as methods for capturing the interaction between the distribution and transmission system. In FY17, OE is supporting work at Sandia to develop distribution level models using OpenDSS that incorporate distributed energy storage, as well as solar and demand response models. Better models for energy storage alone are not sufficient. The interaction between solar variability, load variability, demand response capabilities, and distributed energy storage are required to accurately model the benefits of energy storage in the evolving grid of the future. At PNNL, OE is supporting further advancement of the BSET and Sizing tools mentioned above into a distribution level storage design tool. Both tools currently provide a highly-detailed assessment of the local value of storage but are unable to capture the value at the distribution level with the same degree of fidelity.

Recommendation 4: Develop operational models and verify advanced controls

Advanced energy storage controls is an active area of research for DOE OE and is supported through several projects at Pacific Northwest National Laboratory and Sandia National Laboratories. With support of OE, PNNL is teamed with AVISTA and the State of Washington to develop an optimized dispatch controller for a 1MW/3.2 MWh V/V Redox Flow Battery system installed in Pullman, WA. This controller utilizes a deep understanding of the battery performance as a function of state-of-charge, round trip efficiency, power output, and ambient temperature to determine optimal dispatch of the battery to provide maximum economic benefit. OE through Sandia National Laboratories has developed advanced controls for optimal utilization of energy storage assets in the distribution and transmission infrastructure. OE plans to extend this work to accommodate DES. In FY17, OE will support work at Sandia to develop distribution level models using OpenDSS that incorporate distributed energy storage, as well as solar and demand response models. A focus of this effort will be to develop advanced control strategies that incorporate the characteristics of various distributed resources to maximize the benefits of DES. Sandia is also developing approaches to utilize improved distribution level models in transmission level simulation tools like General Electric's PSLF. A parallel effort is in place to work with the DOE energy

storage demonstration projects to collect operational data to update models, and to demonstrate new algorithms. The results will be disseminated by publishing case studies.

Recommendation 5: Assess the applicability of existing utility-scale codes and standards, and DG codes and standards to smaller-scale distributed storage

OE, through Sandia and PNNL, has continued to facilitate industry engagement in the development of energy storage performance and safety codes and standards. Since 2010, key research staff at the Labs have been engaged in industry wide working groups to determine performance standards for energy storage systems under a variety of utility scale applications. These performance standards are vetted by developers and utilities on field deployed systems and necessary modifications are captured in yearly revisions of the document (http://energymaterials.pnnl.gov/pdf/PNNL-22010Rev2.pdf). DOE is also supporting adoption of these standards within the international storage community to ensure the standards US companies are adopting are in place across the globe. Sandia and PNNL are also actively engaged in facilitating the development of uniform safety codes and standards within the energy storage community and interact with the storage community through the OE led Energy Storage Safety Working Group. While most efforts to date have focused on codes and standards for utility-scale systems, developing codes and standards for small-scale distributed storage has seen increased interest within the working groups.

Recommendation 6: Further leverage the DOE's unique role as an unbiased arbitrator with technical expertise

Under the direction of OE, Sandia National Laboratories and PNNL work with Academia, Energy Storage manufactures, Project Developers, and acts as a clearinghouse for technical and policy information pertaining to the implementation of Energy Storage in the grid. Work involves but is not limited to PUC informational workshops, ES workshops that explain ES, how it works, and its application. Presentations at various ES conferences, and publications of various journal articles and white papers pertaining to ES. This information is made available in an archival website at www.sandia.gov/ess/. DOE through the labs also organizes two energy storage conferences namely Electrical Energy Storage Applications and Technologies (EESAT) in its sixteenth year and Energy Storage Safety and Reliability Forum (EESF) that bring together major stakeholders to address critical issues of importance for the energy storage industry.

Recommendation 7: Assist in the deployment of new standards and codes

OE through Sandia National Labs and PNNL is supplying technical expertise for the development of the two most prominent new safety standards for energy storage systems: UL 9540 for energy storage equipment, and NFPA 850 for energy storage installation. In addition to safety standards, Sandia and PNNL co-published the definitive performance assessment protocol for energy storage systems which is being used as a draft in the development of the relent section of IEC TC120. This follows a long history of engagement with standards such as IEEE 1547. In parallel, teams at national labs are developing a new recommended practice for assessing the service specific performance of many types of DER, including batteries; fuel cells; and demand response, on an even basis.

Recommendation 8: Develop technologies that increase the performance, cost effectiveness and safety factor of DES systems.

OE is helping to enable technologies that meet needs within grid storage through multiple avenues. This is done through extensive performing testing at OE supported resources such as Energy Storage Testpad at Sandia. Partnering with commercial energy storage suppliers, the labs assess the performance, life-cycle metrics and reliability of their technologies through empirical studies of these technologies. The labs also provide guidance and advise to help energy storage providers, and ancillary service providers such as developers of safe charging algorithms identify how to best implement their capabilities in stationary storage markets and use cases. The labs also support the industry to make critical assessment of commercially available battery technologies for performance and safety through rigorous laboratory testing and evaluation. The labs also work industry stakeholders to develop performance protocols to enable a uniform methodology for assessing and reporting on performance of energy storage. Such procedures enable potential consumers to understand the performance and to help assess the cost effectiveness of a particular energy storage solution.