Securing the 21st–Century Grid: The Potential Role of Storage in Providing Resilience, Reliability, and Security Services

Recommendations for the U.S. Department of Energy

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ELECTRICITY ADVISORY COMMITTEE

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1 Introduction

The Electricity Advisory Committee (EAC) Energy Storage Subcommittee continues to examine the role of energy storage as an element of the future grid. Energy storage technologies and the U.S. energy storage industry are changing, and the EAC is focused on understanding the roles of energy storage as a component of the modern electric grid. These roles may contribute to reliability, resiliency, system integration, and other functionalities for customers and for the electric system more broadly. Significant cost reductions in energy storage in recent years, coupled with emerging high-value uses, may provide new opportunities for energy storage deployment, and the needs of the modern grid can help shape the agenda for basic and applied research for energy storage technologies and solutions.

2 Approach

In this context, the Energy Storage Subcommittee facilitated a workshop that brought together experts from the industry and from relevant government entities to discuss ways that energy storage might support a modern, reliable, and resilient 21st-century grid for the United States. The purpose of the workshop and the resulting work product is to advise the Department of Energy (the DOE) about emerging and important storage-related issues.

An overview of the panel discussions and the insights gained from the workshop have been summarized in this work product with the hope of providing insight into the role of energy storage as part of a secure and resilient modern electric grid and to provide recommendations for the DOE in research and development needs related to energy storage.

The workshop was held on June 8, 2017, and was a facilitated, discussion-oriented public session with invited experts and commenters. The primary goal of the discussion was to explore the potential role for storage in supporting a reliable, resilient, and secure 21st-century grid for the United States. The workshop was organized into four panels with energy experts presenting on the related topics. The topic areas included Power Sector Vulnerabilities, Advances in Energy Storage for System Reliability and Resiliency, Storage and Microgrids – New Applications, and Regional Resiliency and Security with Bulk Storage. The opening discussion was focused on the opportunity for improved asset utilization in the power sector with a focus on using storage to help increase asset optimization. The EAC members and commenters were also asked to consider key questions, including what types and amount of energy storage might provide value to the electric power sector to enhance grid reliability and resilience; how might storage address grid vulnerabilities that last seconds, minutes, hours, days, or months; and whether there is a role for the DOE in facilitating high-value basic and applied research in support of these potential uses of storage.

Throughout the day, EAC members and commenters were asked to provide written and verbal feedback on the topic areas with a focus on recommendations for the DOE to determine the potential for storage. The recommendations being provided to the DOE are based on the discussions of the EAC, which were informed by the panelists and commenters.

3 Key Findings

Through the panel discussions, key themes emerged. The panelists noted that energy storage has been deployed cost effectively and is bringing value to the grid. It is a dynamic resource that can support non-dispatchable and distributed resources. The discussion also recognized that storage has challenges that still need to be addressed.

3.1 Power Sector Vulnerabilities

Power sector vulnerabilities that were discussed included human-induced disruptions, cybersecurity attacks, natural causes, and extreme weather events. Most of these events occur at a local level. As such, local storage could help to ride through short-term outages and, with appropriate regulatory and rate designs, local storage combined with photovoltaics could provide for greater resilience.

The panel also discussed the use of storage to address the vulnerabilities created by increased distributed generation on the system. Storage is a dynamic resource that can support non-dispatchable resources; it has flexibility to be applied for services including frequency and voltage support. With increased solar penetration, storage will need to be used to manage changes stemming from distributed generation impacting the bulk power system.

The panelists also discussed potential barriers to implementation, including the potential risk of fire from different battery types. Storage siting and permitting can require significant effort to ensure that storage is safely and securely implemented.

The panel discussion generated a number of key considerations including the need to understand the means to value storage across multiple services or value stacks, e.g., at the distribution or bulk power system level, and/or as a market participant with the provision of services. Disparate but significant efforts are underway at the state, regional, and federal level regarding value assessment. Informing and educating on the value assessment efforts is needed.

Additionally, the question was raised whether storage might increase vulnerabilities and risks rather than address system vulnerabilities. Finally, the need to understand the best applications and types of storage based on the temporal and system requirements was recognized.

3.2 Advances of Energy Storage for System Reliability and Resiliency

Based on lessons learned in California, where over 1.3 GW of storage will be deployed by 2020, energy storage is a key reliability tool that is used to support a changing and more dynamic grid. In many cases, it is faster to implement than generation facilities and it can be more cost effective than alternative reliability solutions. There is still a need for market designers and regulators to understand the technology and determine the best methods to value storage as a reliability solution. In some cases, jurisdictions do not have a requirement to include storage as a resource as part of integrated system planning.

Applying storage as a resilience solution is more challenging. Several states are exploring storage as one element in their overall emergency planning. The addition of storage can aid with overall resource diversification, and thus increase resilience in the face of random events such as the loss of the large natural gas storage facility at Aliso Canyon in California. Storage can assist with resilience via optimization of existing fossil fuel, transmission, and distribution infrastructure; provide isolated regional or local power; and aid restoration and startup of systems. The panelists did discuss microgrids as a resilience solution with storage as one of many resources. Although storage is increasingly being considered an option in emergency-related energy planning, storage and new technologies may not be understood or valued for resilience. Currently, there are cost and technology barriers to utilizing batteries for longer-term outages.

3.3 Storage and Microgrids – New Applications

The first panelist described a microgrid project for a military base that leveraged storage as one element of the pilot. The pilot objectives included lowering costs, increasing renewable utilization, and increasing resilience. The project included an economic analysis including asset optimization to determine the cost-effectiveness of the microgrid with a specific focus on storage. The microgrid with the battery were cost effective if all value streams, including market participation, were fully utilized. The microgrid pilot demonstrated that the project could be cost effective and increase reliability.

The second panelist discussed storage as a cost-effective means to enable San Francisco's carbon emissions goal. Storage is being utilized in combination with renewables to support distributed generation management at the distribution system. Storage and solar combined are also being used to increase resilience for community-based critical infrastructure. Lastly, the panelists indicated that there is additional benefit and lessons to be learned with increased electric vehicles and behind-the-meter storage. The third panelist also discussed the use of storage to enable carbon emission and reliability goals. He also noted that storage supports increased market competition. The final panelist presented on the use of storage for increased resilience for critical infrastructure sites, specifically military bases. He has conducted trade-off analysis looking at a range of energy resource options. The analysis included criteria for costs and resource availability to support resilience. His analysis found that batteries sized to provide electricity for outages up to a day were cost beneficial but that there is also a need to identify resources that could support more demanding objectives including longer-term outages.

The panelists and attendees were asked what challenges storage faces to provide multiple value streams, including resilience. The panelists recognized that storage could be used for multiple value streams. However, not all value streams can be realized simultaneously, nor do regulators recognize all identified value streams. In particular, regulators should look at avoided or deferred transmission and distribution costs enabled by storage. It was also recognized that the definition, metrics, and value of resilience may be highly dependent upon specific applications making it more challenging to assess the cost-effectiveness of storage (or any other energy resource) to address resilience. One panelist proposed working with the insurance industry to understand how they value resilience in economic terms such as lower premium costs as one way of valuing resilience-based investments.

3.4 Regional Bulk Power Adequacy Resiliency and Security with Bulk Storage

The technology is dependent upon geology and geography. It can provide storage at scale for renewable generation as well as ancillary services. Compressed air energy storage (CAES) faces permitting and financing challenges as well as initial expensive startup costs for engineering. As is the case in other storage applications, CAES can provide multiple value streams; it can participate as a generation asset as well as be a participant in the retail electricity markets, providing ancillary services.

Key questions about applications for bulk storage were consistent with other storage applications. Questions included how to recognize the value of multi-day storage capabilities provided by CAES, and how CAES could be considered in regional and local integrated planning.

Though not addressed in this workshop or this paper, there remain important questions about the capability of storage to ensure bulk power adequacy in a grid with increasing levels of weather-dependent generation such as wind and solar. While storage may well be able to address daily fluctuations of wind and solar, several recent analyses suggest that, at very high wind and solar penetrations, balancing multi-day, weekly, and seasonal variations in resource availability may require substantial “overbuild” of storage to be used at ever-lower rates, thus increasing per-unit costs.

In closing, EAC members were asked for final thoughts regarding the DOE’s role in supporting storage applications focused on resiliency and reliability. Key considerations included the opportunity to leverage public/private partnerships to continue R&D and commercialization of storage applications. One recommendation included providing educational information for businesses that provide a practical framework for comparing and thinking about different types of technologies and use cases/applications. Additionally, the DOE could continue to support basic applied research for storage technologies and applications.

4 Recommendations

On the basis of its internal discussions, which were informed by the panels, the EAC has identified the following three recommendation areas for the DOE to consider.

Recommendation #1: The DOE should continue to educate and inform regulators on efforts to assess the value of energy storage technologies as it relates to reliability, resiliency, and security.

Keeping pace with the rapidly evolving, wide range of energy storage technologies and their myriad applications is challenging. Decision-making is further complicated because of the technologies’ unique ability to absorb and release energy from the grid. The DOE should continue to work collaboratively with regulators and other key stakeholders to help them navigate the options and determine what best meets their policy objectives and operating conditions. The DOE should expand efforts to develop models, tools, and technical documents that help regulators and policy makers evaluate energy storage technology types and uses—emphasizing lessons learned/best practices from OE demonstration projects, other DOE-supported efforts, and those that are developed independently of the DOE (where practical). The DOE could leverage its grid modernization efforts in the development and dissemination of these capabilities more broadly, which can foster a better understanding of the potential benefits of energy storage. Without the necessary education and tools, approval and implementation of key technologies will lag.

Recommendation #2: The DOE should continue and further emphasize its research and development on specific power system security requirements.

Energy-storage technologies are particularly well suited to addressing power system security requirements, and thus focused research and development is appropriate. Furthermore, the DOE should continue its research that addresses the value of energy storage to power system reliability and adequacy under a variety of future grid scenarios, involving different resource mixes. It should also support basic and applied research for energy storage technologies and to address deployment barriers, including energy and power densities of energy storage technologies, which may be important considerations in certain (e.g., distributed) deployment settings.

Recommendation #3: The DOE should continue to examine power sector vulnerabilities.

Continuing its assessment of potential reliability and resilience threats to the electric power system, and evaluating the brittleness of existing and potential future power system designs to such threats, is critical. This examination can form the basis of further study to examine the unique role and capability of energy storage to address and mitigate such vulnerabilities. To the extent possible, this recommendation should be carried out with other relevant and interested stakeholders, including reliability organizations, the electricity industry, the National Academy of Engineering, and relevant regulatory bodies.

Appendix: Panelists

Power Sector Vulnerabilities

The panel discussions focused on a range of power sector vulnerabilities and the considerations for use of storage to address the vulnerabilities. The panelists included Granger Morgan, Chair of the Grid Resiliency Committee of the National Academy of Sciences; Damian Sciano, Director of Distributed Resource Integration at Consolidated Edison; and Mark Lauby, Senior Vice President and Chief Reliability Officer at NERC.

Advances of Energy Storage for System Reliability and Resiliency

The second panel discussion focused on Advances of Energy Storage for System Reliability and Resiliency. The panelists included Fred Hoover, Senior Program Director at the National Association of State Energy Officials; Mark Irwin, Director of Energy Contract Management at Southern California Edison; and Praveen Kathpal, Chair of the Board at the Energy Storage Association.

Storage and Microgrids – New Applications

The third panel discussion focused on New Applications for Storage with the panelists providing examples of storage applications that supported renewable- and resilient-energy goals. The panelists included Paul Hibbard, Principal at Analysis Group; Jessie Denver, Energy Program Manager at the San Francisco Department of the Environment; Mark Vanderhelm, Vice President for Energy at Walmart; and Ariel Castillo, Senior Program Manager at the U.S. Department of Defense.

Regional Bulk Power Adequacy Resiliency and Security with Bulk Storage

The final panel discussion focused on bulk storage applications with Richard Walje, CEO of Magnum Compressed Air Energy Storage, describing his CAES project. The panelist described the technology, challenges and applications of CAES.