



August 31, 2020

Ms. Rima Oueid
U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585

RE: Department of Energy's Energy Storage Grand Challenge RFI

Ms. Oueid:

IEEE-USA, in partnership with the IEEE Power and Energy Society, appreciates this opportunity to respond to the Department of Energy's *Energy Storage Grand Challenge* RFI. We believe that energy storage technology has enormous promise, but also that the technology is not yet fully mature. We applaud the DOE's efforts to help accelerate the maturation process by investing in the research necessary to make energy storage a viable and reliable part of our energy system. We hope that our insights and expertise are helpful to you in this project.

Please contact IEEE-USA's Senior Legislative Representative Aline McNaull at (202) 530-8355 or a.mcnaull@ieee.org if you have any questions.

Sincerely,

A handwritten signature in black ink that reads "James M. Conrad".

Dr. James Conrad
IEEE-USA President

Section 1:

D.1 USE CASES

D1.4 Specific Use Cases

D.1.4.1 Facilitating an Evolving Grid^{1, 2}

D.1.4.1.1 What kinds of emerging individual/business/local/state/regional goals could be supported by this use case?

Energy storage in the grid supports the following goals:

1. For states - renewable and clean energy targets.
2. For the national economy - economic growth, new business creation, and job opportunities in the electric power sector.
3. For the power industry - a low carbon future of the electric infrastructure.

Energy storage is beginning to enable convergence across key areas with significant potential to affect the future of the electricity industry. These opportunities include rapid growth of renewables, initiatives by state and local bodies to pursue clean energy technologies, electrification of transportation, and enhanced grid reliability and resilience through modernization of the electric grid. Large-scale integration of energy storage into the electric grid infrastructure will certainly have a transformative effect on that infrastructure. Energy storage will provide numerous benefits that have bearing on how the future grid operates, providing grid operators with a flexible asset that can respond to situations that could not be readily handled in the past. Energy storage will play a major role in integrating renewables. The amount and type of energy storage solutions needed for renewable firming continues to evolve, making even more obvious the significant gaps in what current energy storage technologies can provide. As states and cities continue to push towards higher renewable targets, with some states moving towards 100% clean energy, the need for lower cost energy storage – including long duration and seasonal storage – becomes ever more important.

D.1.4.1.2 What performance requirements for storage would be required to achieve these goals?

Energy storage integration

Requirements include:

Energy storage installations with higher power capacities and higher working voltages;
Streamlining engineering to hybridize and co-optimize energy storage design with the rest of the system. Engineering practice related to balance of system needs significant amounts of development to realize lower costs and system reliability.

Developing more effective controls, sensors, and energy management systems to provide for optimal storage dispatch and use;

Integration of energy storage in distribution and transmission operations at an early stage along

¹ Energy Storage Primer, IEEE PES April 2020 (https://resourcecenter.ieee-pes.org/technical-publications/white-paper/PES_TP_WP_NRG-Storage.html)

² Energy Storage Opportunities and Research Needs, IEEE PES June 2020 (https://resourcecenter.ieee-pes.org/technical-publications/white-paper/PES_TP_WP_ESORN_063020.html)

with energy management systems for system control and dispatch. Higher levels of integration of distributed controls and sensors to seamlessly manage bidirectional power flows.

Designing modular power converter architecture to minimize system complexity, improve reliability, and reduce integration costs.

Developing industry standards for secure communication, cybersecurity, and interoperability
Further R&D is needed for engineering Energy Storage Systems (ESS) at scales ranging from behind-the-meter storage to large grid-connected energy storage plants.

Modularity and power conversion systems

To keep pace with the expanding scope of storage applications, flexible power conversion architecture is needed. Modular converter topologies constructed from highly optimized power electronic building blocks are widely recognized as an effective strategy for enabling flexible utility-scale power conversion systems. Modular structures make it possible to develop both high-power converters for direct medium-voltage grid connection and low-voltage distribution-level conversion systems using the same standard set of tools. Within a modular design framework, redundant converter modules can be used to improve system fault-tolerance and increase overall reliability.

Renewable integration

In order to support projections of cost-performance of ESS, there is a need to advance knowledge and methods for providing accurate cost-benefit estimates of operation of energy storage integrated with renewables resources over the entire range of operating conditions. It is necessary to obtain high fidelity, scalable dynamic models for energy storage systems and other distributed inverter-based systems to assist operations and planning studies. It is necessary to improve methods for forecasting and modeling integrated operation of renewables plus storage so as to provide tools capable of minimizing uncertainty-related risks and maximizing the benefits from energy storage assets.

Interoperability and cybersecurity

Defining cybersecurity requirements and threat models for energy storage systems is still a topic that generates confusion and must be streamlined.

D.1.4.3 Electrified Mobility

D.1.4.3.2 What performance requirements for storage would be required to achieve these goals?

Further advances in battery technologies, especially systems with higher energy density, cycle life, and safety are needed to reduce range anxiety and serve battery requirements beyond passenger cars. Truck electrification is already underway. Electric aviation is the next frontier, where much higher energy and power-density battery technologies will be needed. As electrification extends from cars to larger heavy-duty vehicles, its impacts will likely be greater than initially predicted. Further advances in energy storage technologies will increase vehicle ranges and result in rapid adoption in fleets.

Electrification of transportation requires major upgrades to our power distribution infrastructure. Integration of fast charging infrastructure implies a different type of energy storage relative to many other grid services.

Large-scale electrification of transportation will likely be the largest change to affect the power distribution system in the coming decades. Electrification of transportation not only represents a significant demand for electricity, but it will require major upgrades to distribution system infrastructure, especially in handling higher peak loads and variable load profiles.

Transportation companies will need to work closely with the power industry and power engineers to assure seamless operation of electric transportation with the power system.

D.1.4.4 Interdependent Network Infrastructure

D.1.4.4.1 What kinds of emerging individual/business/local/state/regional goals could be supported by this use case?

Major goals that could be aided by closer networking of the systems include cleaner air and reduced cost of electric services. Examples include:

Transmission

Energy storage use at the transmission level is beginning to be considered seriously, largely in response to utility programs opening up their bidding processes such that energy storage can be used to provide key services such as peak shaving and fast frequency response.

Distribution

Storage can postpone distribution and substations upgrades. In urban areas, peak power continues to grow at a rate of 1%-3% annually, including the increasing electrified mobility mentioned earlier, causing loads to exceed substations capacity. Conventional substations upgrades (like adding a new transformer) come in large blocks (~30% of the total station capacity) and are expensive. Energy storage can be used to defer these large upgrades.

Perhaps the most common customer and distribution use case is peak load shaving for avoidance of demand charges, because in this application energy storage can often have a favorable payback time even today.

Energy storage for backup supply and power quality event mitigation is also common and is economically justified as a form of insurance against the cost of an interruption. In this case the primary value of the energy storage is in “black-sky” applications, but there is also considerable interest in using the storage during “blue-sky” conditions to improve the economics of this application.

Microgrid

Microgrids are typically centered around generators providing electricity or Combined Heat and Power (CHP) that often run on natural gas or diesel. The addition of variable renewable generation—namely solar and wind—into new and existing microgrids is the primary driver of interest in ESSs. Although an ESS can provide benefits by reducing fuel consumption of fossil-fueled generators, the integration of renewable generation is the key benefit provided by ESSs for microgrids.

D.1.4.4.2 What performance requirements for storage would be required to achieve these goals?

Transmission

Long-duration storage makes sense along transmission lines, especially near large-scale renewable generation stations. Such installations can be used to defer upgrades, store excess energy from renewable sources, and serve as a generation station for communities in case transmission lines are cut.

Distribution

As renewable energy penetration increases and conventional power plants are retired, the need is emerging for energy storage capable of cost-effectively supplying electric services for a day or longer. It is likely that longer duration storage with capacity to handle days and weeks will be needed within a decade. This is an area where there are virtually no readily available grid-level technologies that can address potential needs

Microgrids' integration control systems

Although an ESS can provide benefits by reducing fuel consumption of fossil-fueled generators, the integration of renewable generation is the key benefit provided by ESSs for microgrids. Other drivers for this trend include: the desire to improve the resilience of electric power supply for customers; the need to expand reliable electricity service to new areas, particularly remote areas; rising electricity prices; and innovations in business models and financing

Integration between ISO markets, utility controls, and building operations can lead to optimal utilization of energy storage and distributed generation. However, to operate integrated control systems requires access to data and forecasting models. Data sources are available, but they are mostly in proprietary format and not always available in real-time. Battery Management Systems (BMS) are still difficult to access for data gathering, let alone integrate with storage systems controls. There is an opportunity for improved data integration and intelligence in microgrids. It is important to find models that allow batteries to be operated for grid service by the utility and grid operators, and to be available in case of outages.

D.1.4.5 Critical Service Resilience

D.1.4.5.1 What kinds of emerging individual/business/local/state/regional goals could be supported by this use case?

Increasing power outages around the world are forcing utilities to confront the limits of the traditional electric infrastructure. Places such as the U.S. East Coast, West Coast and the Gulf area in the United States, and countries including Japan are exploring new options to mitigate impacts of hurricanes, wildfires, and typhoons and earthquakes. Growing numbers of utilities are shifting strategies to embrace microgrids as a solution, in part due to the new standards in place that provide specific advantages and flexibility to microgrids that include part of the electric power distribution network.

D.1.4.5.2 What performance requirements for storage would be required to achieve these goals?

Grid-level simulation tools are essential to study economic and reliability benefits of ESS deployment, in spatial scales from transmission network to active distribution feeders (e.g., electric vehicle charging infrastructure, demand response, distributed generation), and in temporal scales

from short-term stability and reliability analysis to long-term economic analysis and planning. In the case of Battery Energy Storage Systems (BESS), there is a need to improve battery models to make operational and performance improvements at the storage systems. Advanced processes, methodologies, and tools - including tools for time-series analyses - are required to optimize siting and sizing of ESS, as well as perform accurate benefit-cost analyses, including lifecycle economics and market participation benefits.

D.1.4.6 Facility Flexibility

D.1.4.6.1 What kinds of emerging individual/business/local/state/regional goals could be supported by this use case?

The flexibility of facilities can greatly help facility owners to manage their electric consumptions. For example:

1. Electric customers can minimize utility bills by flexibly managing their consumption with energy storage being a buffer for arbitrage.
2. Utilities can defer infrastructure investment by using energy storage to flatten the load duration curve.

D.1.4.6.2 What performance requirements for storage would be required to achieve these goals?

Developing comprehensive approaches on how to place value on energy storage;
Establishing compensation strategies for the wide array of services that energy storage can provide; and
Incorporating energy storage into market rules and resource adequacy considerations.

D.3 TECHNOLOGY PATHWAYS

D3.1 The ESGC road map appendix identifies current R&D DOE activities on a variety of storage technologies. What additional technologies and R&D pathways have the potential to meet the use case requirements?

Battery energy storage in the electricity infrastructure is relatively new. Storage systems that are currently being deployed are based on existing batteries such as Li-ion batteries and lead-acid batteries. These are an outgrowth from consumer electronics and automotive industries. Engineering large storage systems for grid applications requires form factors that be easily scaled from kW to multi-MW sizes without incurring significant balance-of-system costs. And in the case of emerging technologies such as flow batteries, there has not been manufacturing at scale to achieve true advantages of these technologies.

D3.2 For a given technology (e.g. flow batteries, thermal storage, compressed air, balance of system/ power conversion technologies etc.):

D.3.2.1 What are the major challenges to commercial viability?

The demand for energy storage is significant and cannot be met by any single technology. In battery technology, there are well established electrochemical battery industries, lead-acid, Li-

ion, and alkaline rechargeable (NiCd, NiMH) and primary (Zn-MnO₂) batteries. Laboratory successes with new battery chemistries are being announced almost daily, but even for the most promising options it will take years before they are ready for field deployment. Further longer-term research and development is needed to successfully develop such promising technologies like solid-state lithium, redox flow, and alkaline batteries. These technologies potentially have most room for improvement in the coming decade. These technologies will not flourish without a coordinated effort to support research and scale up from the lab to manufacturing and commercial products.

D.3.2.2 What additional testing capacity or capabilities would help accelerate technology development?

Significant investments are needed to transition energy storage technology from the lab to commercial products. Lab prototypes are not manufacturable at low cost and with high quality. For example, the process of engineering a battery cell for manufacturing is still an iterative and costly process. Economies of scale cannot be achieved at modest manufacturing capacities. A modest sized lead-acid or Li-ion manufacturing plant will have a capacity in excess of a GWh per year, and in many cases much larger.

Bringing new battery technologies to market is challenging and capital intensive. Manufacturing variations are the largest during the initial process of scale-up, and before manufacturing equipment, processes, and quality assurance/quality control procedures are established. It may take several months and sometimes years before a manufacturing defect leads to a battery failure. This problem is especially felt by emerging battery companies that are required to offer the same warranties as large established multinational companies can provide but cannot afford to understand and reduce manufacturing failures to quantify their warranty risks.